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LOCOMOTIVE VALVE SETTING

BY

JACK BRITTON

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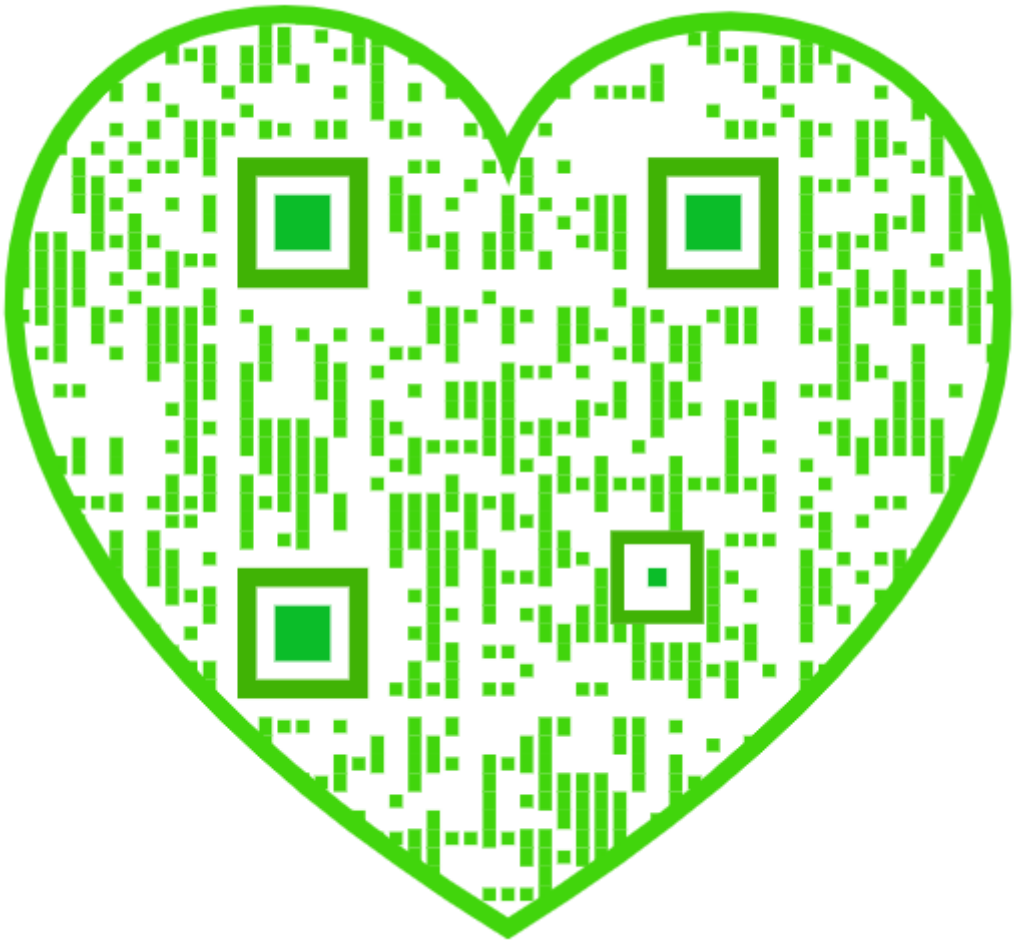

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A Few Useful Shop Hints *on* Locomotive Valve Setting

By

JACK BRITTON

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INTERNATIONAL ASSOCIATION
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FORMERLY APPRENTICE INSTRUCTOR,
LOCOMOTIVE ERECTING SHOP DEMONSTRATOR
AND VALVE SETTING SPECIALIST

FIRST EDITION

THE FEDERATED PRESS LIMITED

MONTREAL, CANADA

1920

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by
Jack Britton

Preface

SAY, BO—DEKKO THIS BIRD !

A real hunky bunch of practical shop stunts FOR a shop man, put up BY a shop man, raised AMONG shop men on the erecting shop pits.

Be a valve setter as well as a sledge hammer artist on frames, cylinders, etc.

You don't have to be a designer to understand these kinks.

Take what you want and forget the technicalities you don't need on the shop end of the game.

Certain unnecessary "dope" which often occurs in shop treatise is cut out from this little shot at a "boomer's" shop dream.

The author realizes what a green hand on the pits is up against in order to gain a living, let alone a thorough knowledge of the game ready for a show down.

This book is the first of a series in the endeavour to show how to crack many of the apparently hard nuts met with during the erection of a locomotive, from the preparation of the pit for main frames, to the finished engine ready for delivery to the round house, including trial trip.

The author, being a shop man, makes no apology for grammatical errors or shop slang.

If you like it, tell the other boys.

If you don't like it, tell me why. Shoot.

JACK BRITTON.

Montreal, November, 1920.

Introductory.

A DESIGNER of Locomotive Valves and Valve Gears aims at the real thing in distribution of steam by way of the valves to the cylinders at each and every reverse lever position, with due regard to obtaining a smart engine, to the general construction of engine, to the service it is intended for and to the economy of fuel consumption.

There are, however, certain difficulties for the designer to contend with which compels him to make certain sacrifices in the lay out of the valve gear from his standpoint, which are more or less pronounced and in evidence when the engine is built and put into service, dependent on the skill of the designer to a great extent.

A valve setter, particularly one whose experience has been somewhat limited, is apt to get puzzled when, after squaring an engine to two given reverse lever positions, that same shows "out of square" in others.

The object of this work is to show clearly how to get the best results in valve setting with due respect to the designer, yet in such a way as to prevent any possible chance of the responsibility of a weakness in design to be passed on to the shoulders of a valve setter, to eliminate the tendency on the part of a certain few who would monopolize this class of work, and to present to the person who is seeking the information, an opportunity to get in on the game more rapidly.

Follow in detail the practice herein, apply same as case requires, leave the errors of motion, etc., to the designer, and you will be playing safe as a shop man.

You will also be gaining that knowledge which will enable you to go after any kind of valve rigging and set the valves satisfactorily with a degree of confidence worth while.

The author realizes that other methods of valve setting are employed, yet, if the green hand "works back" the dope herein he will find himself in a position to grasp and follow most of the stunts he may possibly run into.

The sketches are put up in skeleton form, more or less, particularly with a view to allow of an easy understanding to the beginner.

A designer could pick out many errors from same. We should worry. They suit the purpose for the shop man's benefit.

A beginner should "Get in" quickly on the proper way to keep and use small tools such as calipers, scale, scribers, etc. This should be unnecessary at this time, however, for the "Bohunk" who doesn't "know how" when he "blows" into the Erecting Shop, should get all that's coming to him.

The very elementary details are especially intended for the green hand.

The author gratefully acknowledges the courteous treatment received from "The Pilliod Company," and the privilege extended, granting the use of certain data and sketches of the "Baker Valve Gear."

Chapter I.

A CRUDE ENGINE

AS a rule one has to walk before catching on to the running stunt, likewise, let us "get in" on a crude one way engine. Get familiar with the names of the parts. Figure 1 shows them.

A Piston Valve is represented at "D" and when operating, distributes live boiler steam to both sides of the Piston "K" at the proper time. The valve also allows exhaust steam to escape from the cylinder from either side of the Piston, at the proper time.

Inside Admission Valve

When live steam passes the inner edges of the valve on its way to the cylinder, the valve is called an "Inside Admission Valve." See Figure 1.

Outside Admission Valve

When live steam passes the outer edges of the valve on its way to the cylinder, the valve is called an "Outside Admission Valve." See Figure 10.

Figure 1 shows a valve placed centrally with the steam ports and arranged to just cover them in this position. Note the position of Eccentric Sheave "A" with respect to the Main Pin "B."

Indirect Motion

The arrows in Figure 1 indicate the direction in which this engine must operate. The Eccentric Rod "C" moves in an opposite direction to the valve "D" and the valve rod "E" at all times. For this reason the valve rigging is said to have "Indirect Motion."

This "Indirect Motion" is set up because an Indirect Rocker is used. "H" represents the Rocker Shaft, "H.F." the Upper Arm, "H.G." the Lower Arm.

Direct Motion

When the Eccentric Rod and the Valve moves in the same direction at all times the Valve Rigging is said to have "Direct Motion." A Direct Rocker is used to effect same as shown in Figure 9.

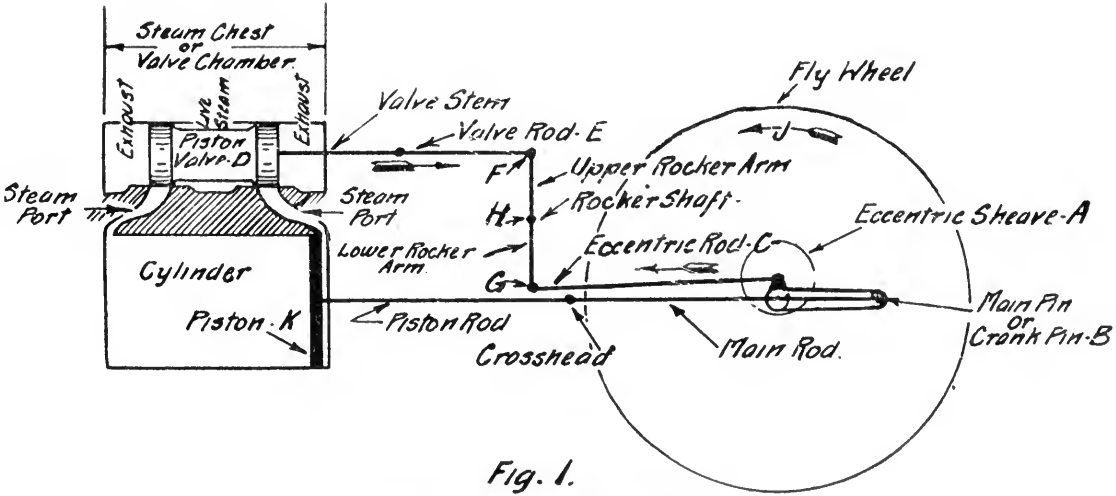


Fig. 1.

Inside Admission Valve

Indirect Motion.

THE DIRECTION IN WHICH AN ENGINE WILL OPERATE

Live steam admitted to Valve Chamber as in the case shown in Figure 1 would not start the engine by reason of the position of the Valve "D" and the Main Pin "B."

Pull the fly wheel around a short distance in the direction indicated by arrow "J" and the movement of the Valve allows steam to pass to Piston "K" to favor the movement. If, however, the fly wheel was pulled around in a direction opposite to that indicated by arrow "J," the engine would not operate. Hence a One Way Engine.

The direction in which an engine will operate depends on three things:—

(1) The Main Valve being "Inside" or "Outside" admission.
(2) The motion of Rocker being "Direct" or "Indirect."
(3) The relative position of Eccentric Sheave to Main Pin.

Live steam passing by Valve "D" through steam ports, acts on Piston "K" during operation, which through the medium of the Piston Rod, Crosshead and Main Rod acts upon Main Pin "B." In this way the reciprocating motion of the Piston is converted into the rotary motion of the Crank Pin. The Crank Pin turns the fly wheel, the shaft of which actuates the Eccentric Sheave. The Eccentric Sheave in turn causes the movement of the Main Valve through the medium of Eccentric Rod, Rocker, Valve Rod and Valve Stem.

To follow the passage of live steam, take the case shown in Figure 1 and turn the fly wheel with Main Pin to position shown in Figure 2. The Valve has moved, which allows steam to pass to and act upon the Piston. Move the engine around until the steam port is fully open as shown in Figure 3.

Note how the centre line of Main Crank stands with respect to centre line of Eccentric Sheave. They form an angle of 90°, i.e., they are at right angles. If the engine is moved around still further, the Valve continues to move but returns and closes the Back Steam Port.

Figure 4 shows the Back Steam Port just closed as the Piston arrives at the full extent of its travel forwards, which means that when the Piston is at either end of its stroke, the valve is just in the middle of its stroke, and again, when the valve is at either end of its travel, the Piston is just in the middle of its stroke. Figure 5 shows a position where live boiler steam is being admitted to the front side of Piston, and

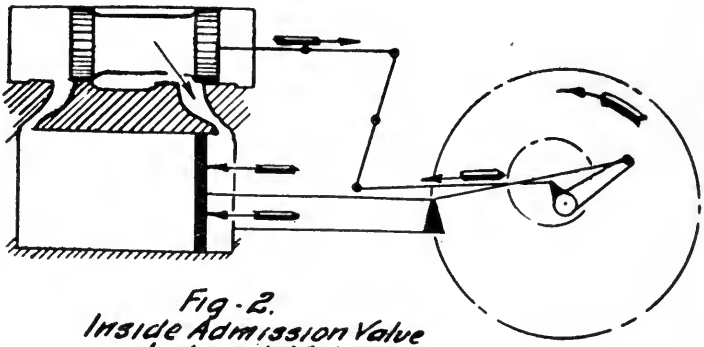


Fig - 2.
Inside Admission Valve
Indirect Motion.

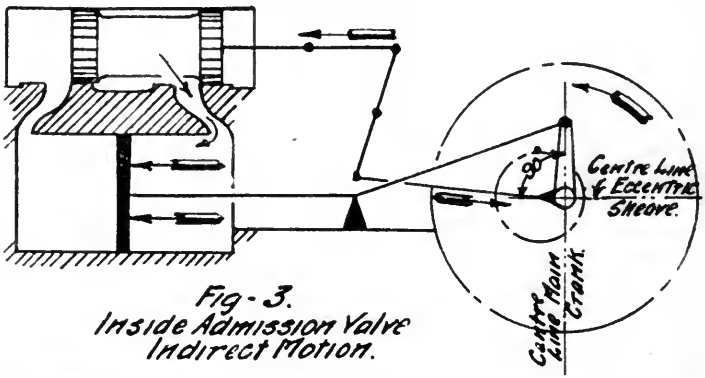


Fig - 3.
Inside Admission Valve
Indirect Motion.

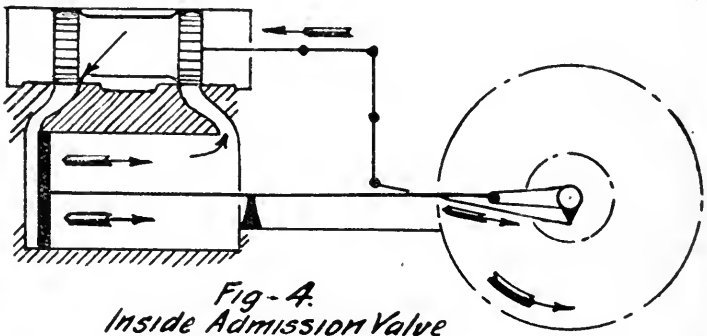


Fig - 4.
Inside Admission Valve
Indirect Motion.

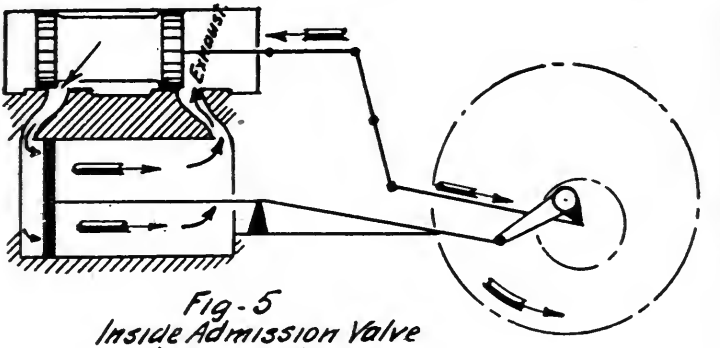


Fig - 5
Inside Admission Valve
Indirect Motion.

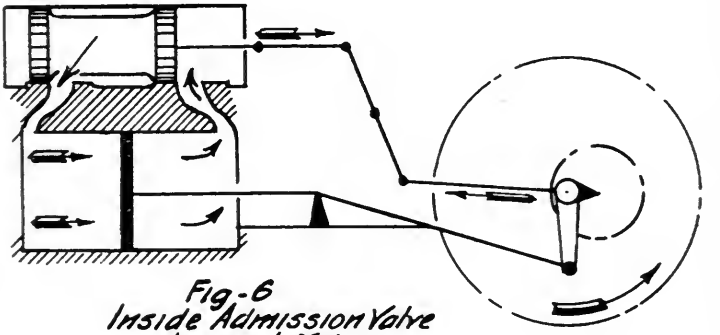


Fig - 6
Inside Admission Valve
Indirect Motion.

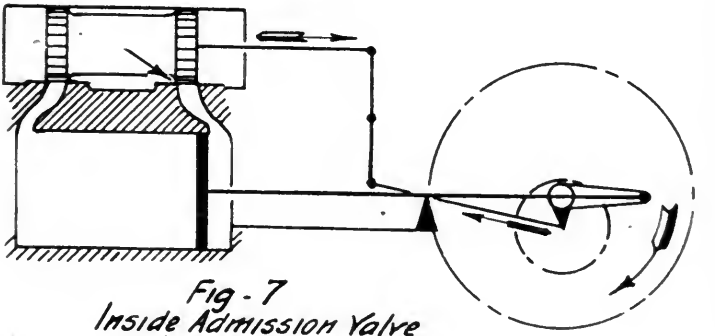


Fig - 7
Inside Admission Valve
Indirect Motion.

owing to the Valve being made to just cover the steam ports when Valve is on the centre of its seat, the steam from the back side of Piston can now escape along through the exhaust passages. Figure 6 shows front steam port fully open to allow live boiler steam to pass to front side of Piston, also a full port opening to allow steam to escape to the exhaust passages from the back side of Piston. If we continue to turn the engine another quarter of a turn, we reach the position shown in Figure 1, thus making one complete revolution. From the description it is seen that live boiler steam is admitted to the Piston during the entire stroke and directly the Piston is on its return stroke, this live steam commences to escape and continues to do so during the entire return stroke. This constitutes a wasteful engine in the majority of cases, although this same arrangement is used to advantage once in a while.

Figure 7 shows an eccentric sheave placed diametrically opposite to the case we have already considered. The engine must move in the opposite direction accordingly.

Figure 8 shows the path of live also exhaust steam after having moved engine around slightly.

If it was seen fit to retain the relative position of Eccentric Sheave to Main Pin as in the case of that shown in Figure 1 and to still use an "Inside Admission" Valve, yet a movement of engine was required in the opposite direction to that shown in Figure 1 then a "Direct Motion" Rocker would have to be used, as shown in Figure 9. Again if the relative position of Eccentric to the Main Pin was decided upon, as in the case shown in Figure 1, also an "Indirect" Rocker had to be used, and yet the engine was required to operate in the direction shown in Figure 9 then an "Outside Admission" Valve would have to be used, see Figure 10.

Steam Lap

Whilst it was known that steam had the power of doing work owing to its expansive properties, a means whereby same could be utilized had to be arranged. In order to do this, the Valve is extended beyond the edges of the ports on the live steam side, when valve is placed on the centre of its seat, and a longer valve travel is arranged by increasing the throw of the Eccentric in order to ensure a full steam port opening at each end of cylinder, during operation. Figure 11 shows everything arranged as in the case shown in Figure 1 except

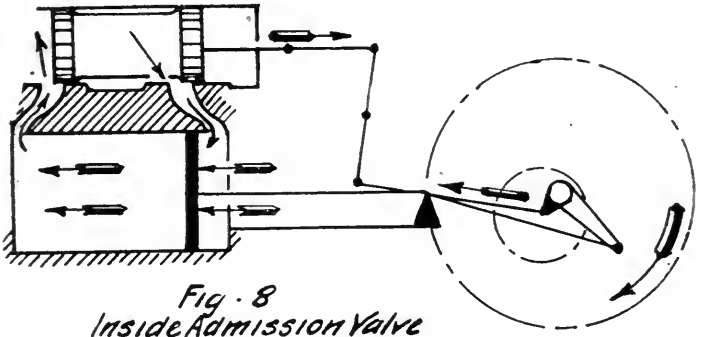


Fig. 8
Inside Admission Valve
Indirect Motion.

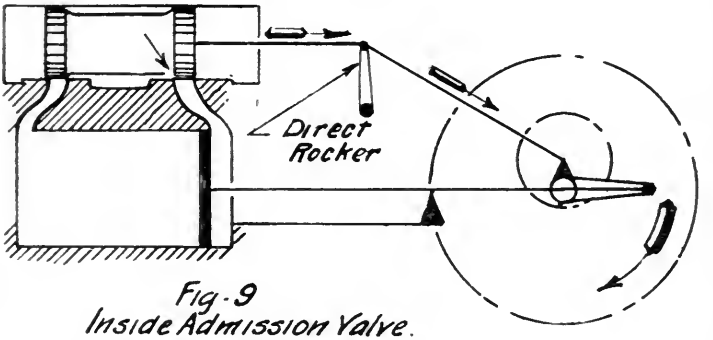


Fig. 9
Inside Admission Valve.
Direct Motion.

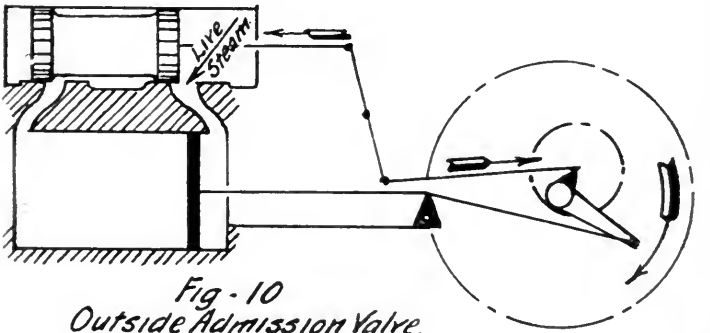


Fig. 10
Outside Admission Valve.
Indirect Motion.

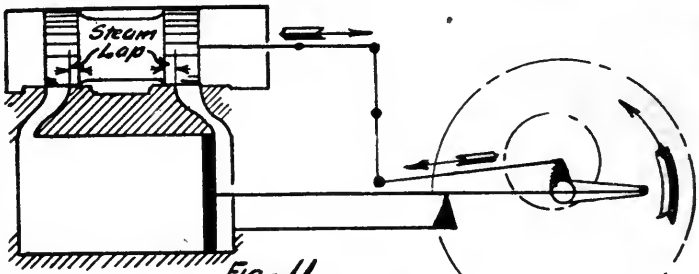


Fig - 11
Inside Admission Valve
Indirect Motion
Steam Lap To Valve.

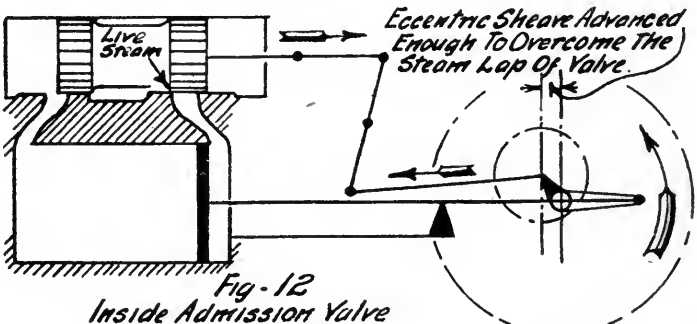


Fig - 12
Inside Admission Valve
Indirect Motion
Steam Lap To Valve.

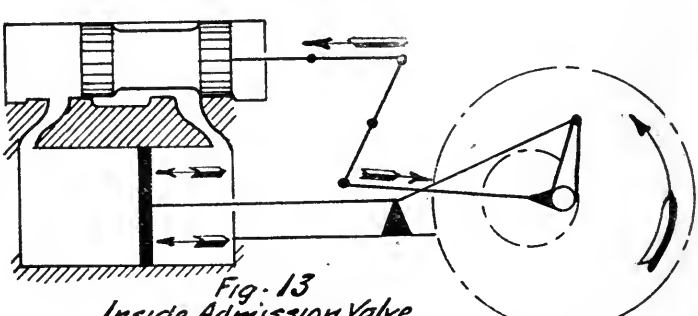


Fig: 13
Inside Admission Valve
Indirect Motion
Steam Lap To Valve.

that Steam Lap has been added to the valve, and the throw of the Eccentric increased.

"Steam Lap" is the amount that a Valve overlaps the steam ports on the live steam sides of the Valve when Valve is in central position.

"Steam Lap" cannot be affected by any changes in the Valve Rigging, other than machining the Valve.

In order to place the valve on the point of opening to admit the live steam to Piston when steam lap is introduced, the Eccentric Sheave has to be moved around the fly wheel shaft, with respect to the Main Pin as shown in Figure 12 and keyed there.

Note the position of Valve, Eccentric Sheave and Main Pin. The relative position of Eccentric Sheave to the Main Pin, when set properly, becomes fixed. A position is shown in Figure 13, with a full port opening under the new conditions. The Piston has not yet reached the centre of its stroke.

The Point of Cut Off

Move the engine round until the valve is just closing the back port, i.e., just cutting off the entry of live boiler steam to the back end of Piston as shown in Figure 14. This is called the "Point of Cut Off."

A Cut Off

"A Cut Off" is the distance the Piston has travelled from the beginning of its stroke to where it has arrived when the valve just shuts the steam port (the back port in this case taken for example) see Distance "A" Figure 14. Before steam lap was introduced, live steam was admitted during full stroke. It is now seen that the supply is cut off before Piston has reached the end of its stroke, the Cut Off depending to a certain extent, on the steam lap given to the valve. There being two steam ports leading to both sides of Piston, respectively, also steam lap being arranged on both sides of Valve, naturally the "Cut Offs" as well as all other events will occur at both ends of cylinder. For the time being let one end of cylinder be considered.

Expansion

Figure 14 shows a position where live steam is trapped in the back end of the cylinder.

Expansion in a Locomotive Cylinder is a property of the volume of steam under pressure, which is trapped in the

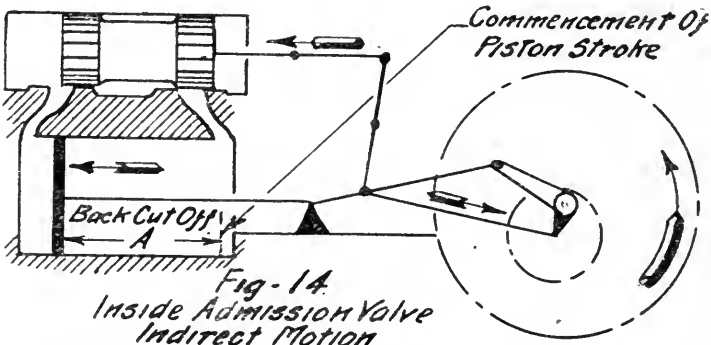


Fig - 14
Inside Admission Valve
Indirect Motion
Steam Lap To Valve

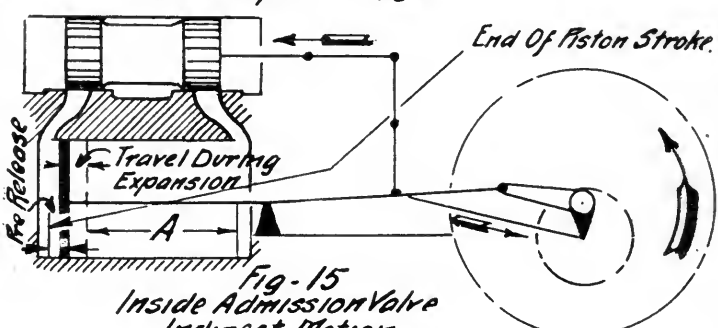


Fig - 15
Inside Admission Valve
Indirect Motion
Steam Lap To Valve
Valve Line And Line On The Exhaust Side.

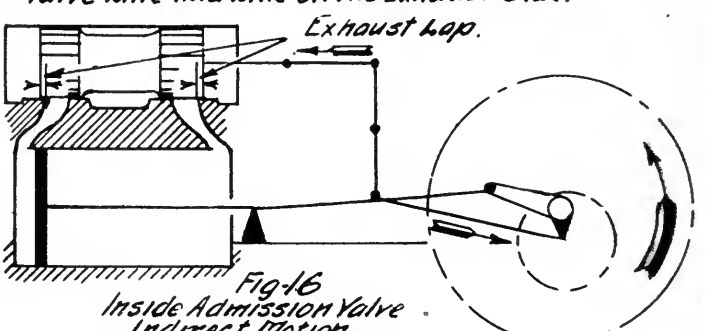


Fig-16
Inside Admission Valve
Indirect Motion
Steam Lap To Valve
Exhaust Lap To Valve.

cylinder when the valve is on the point of "Cut Off," by virtue of which, the Piston is moved until the Valve arrives at the point of release, thus increasing its own volume at a reduced pressure.

The Point of Release

This expansion occurs until the engine is moved around to the position shown in Figure 15 where the Valve is seen to be on the point of releasing steam to the exhaust passage from the back end of Piston.

Pre-Release

Owing to the advance of Eccentric Sheave which was necessary when Steam Lap was added to the Valve, release we find occurs before the end of the Piston stroke is reached, whereas in the case taken in Figure 4, with no steam lap to valve, the Piston reaches the full extent of its travel forward before exhaustion or release commences.

This release before the end of the stroke of piston is reached, is called "Pre-release" and is measured from where the piston is at the time when the valve is on the "Point of Release," to the end of its stroke, see Figure 15.

Exhaust Lap

In past years it was thought by some that this "pre-release" occurred too soon, and in order to set back or retard the "Point of Release" the valve was extended beyond the edges of the steam ports on the exhaust sides of the valve, when valve was on centre of valve seat.

This amount of over lap was termed "Exhaust Lap," see Figure 16. Figures 15 and 16 are alike except that Exhaust Lap has been added in Figure 16. It is easily seen that the engine has to be moved around still further before release can begin to occur from the back end of piston, see Figure 17, which means that the piston has moved nearer to the end of its travel when compared with Figure 16. This shows clearly that when exhaust lap is added the "Point of Release" is delayed and the "Pre-release" is shortened.

Exhaust Clearance

Refer once again to Figure 15 and instead of adding exhaust lap to the valve, take off or machine away equal portions from

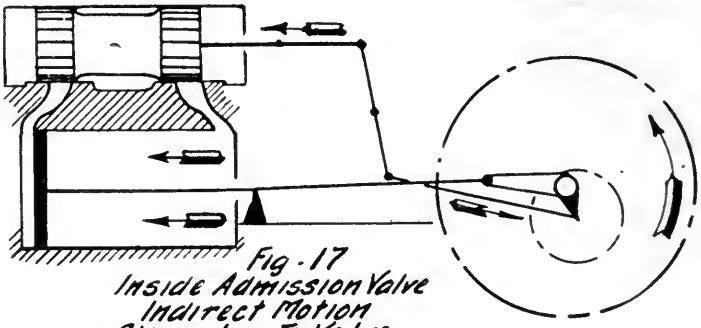


Fig. 17
Inside Admission Valve
Indirect Motion
Steam Lap To Valve.
Exhaust Lap To Valve.

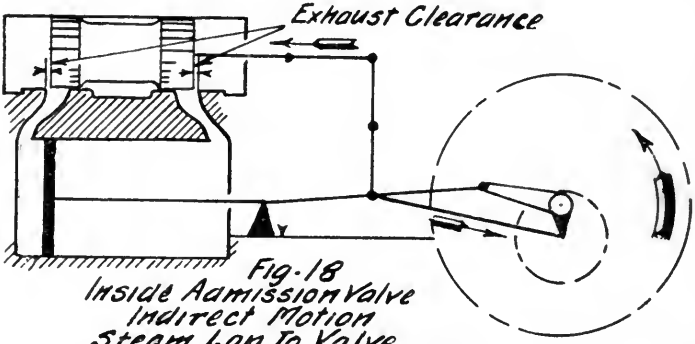


Fig. 18
Inside Admission Valve
Indirect Motion
Steam Lap To Valve
Exhaust Clearance Present

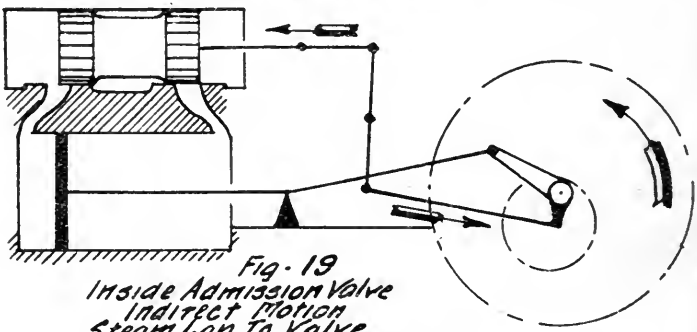


Fig. 19
Inside Admission Valve
Indirect Motion
Steam Lap To Valve
Exhaust Clearance Present.

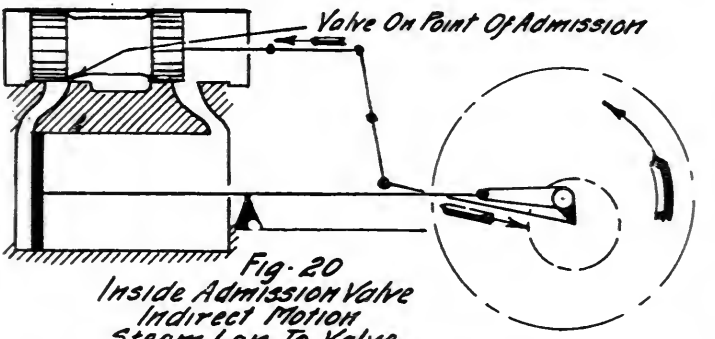


Fig. 20
Inside Admission Valve
Indirect Motion
Steam Lap To Valve
Exhaust Clearance Present

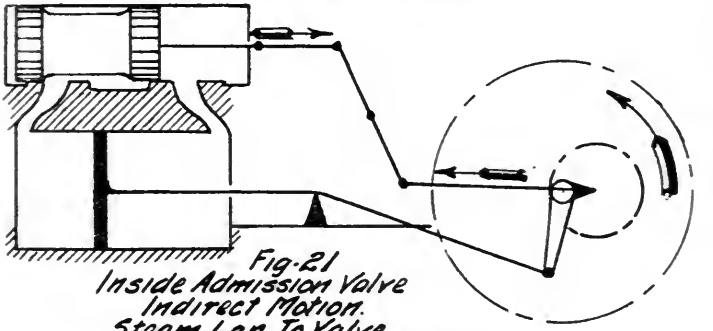


Fig. 21
Inside Admission Valve
Indirect Motion.
Steam Lap To Valve
Exhaust Clearance Present.

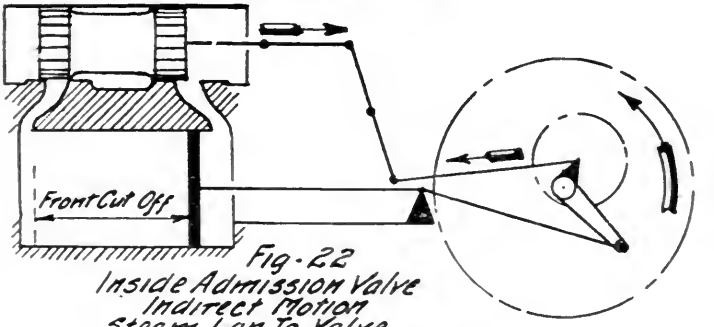


Fig. 22
Inside Admission Valve
Indirect Motion
Steam Lap To Valve
Exhaust Clearance Present

the exhaust sides of the valve We now have, see Figure 18, what is known as "Exhaust Clearance," i.e., the distance between the edge of valve on the exhaust side and the nearest edge of steam port when valve is placed on the centre of its seat. When exhaust clearance is arranged it has the opposite effect to exhaust lap, i.e., release occurs earlier during the stroke of the piston and "Pre-release" is lengthened.

Figure 19 shows the valve on the point of Release, at back port with a valve having "Exhaust Clearance." It also shows the piston farther from the end of its stroke as compared with Figure 17 where Exhaust Lap is present on the valve.

The Point of Admission

Let us continue with a valve having "Exhaust Clearance." Turn engine around until piston reaches the front end of its stroke, see Figure 20. The valve is here seen on the "Point of Admission" for live steam at the front port. Note that the back port is open to release steam from the back end of cylinder to the exhaust passages.

Figure 21 shows a full front port opening for live steam to front end of cylinder. Figure 22 shows valve on the "Point of Cut Off," when live steam is trapped at the front end of cylinder.

Admission

"Admission" occurs during the period between the "Point of Admission" and the "Point of Cut Off." "Admission" is a port opening to admit live steam from the valve chamber to the cylinder by way of the steam ports. Note in Figure 22 that the back port is not yet closed to release.

The Point of Exhaust Cut Off

Figure 23 shows the valve just on the "Point of Exhaust Cut Off," at the back port.

Exhaust

Exhaustion occurs during the period between the "Point of Release" and the "Point of Exhaust Cut Off." Exhaustion or release is a port opening to allow steam which has done effective work to escape from the cylinder to passages leading to the atmosphere or condenser if used.

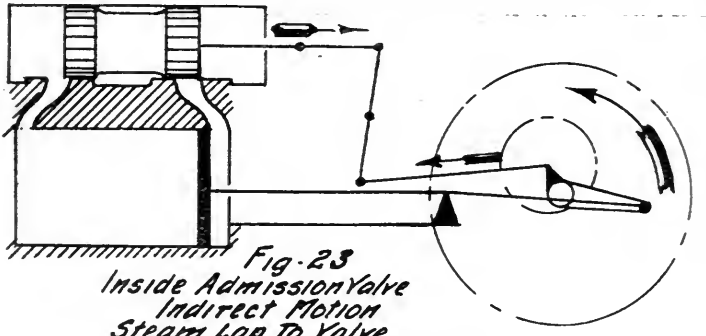


Fig. 23
Inside Admission Valve
Indirect Motion
Steam Lap To Valve
Exhaust Clearance Present

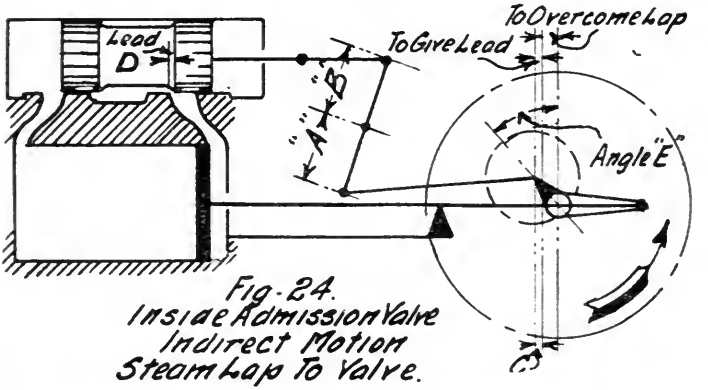


Fig. 24.
Inside Admission Valve
Indirect Motion
Steam Lap To Valve.

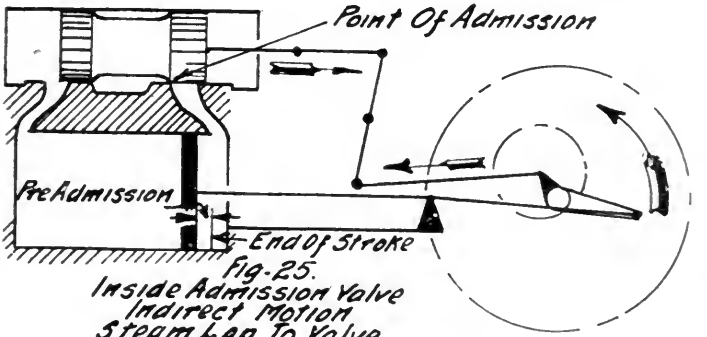


Fig. 25.
Inside Admission Valve
Indirect Motion
Steam Lap To Valve
Exhaust Clearance Present

Compression

The exhaust steam which is trapped in the cylinder when the "Point of Exhaust Cut Off" is reached, is now forced into a smaller volume as piston continues to move towards the end of its stroke.

"Compression" occurs during the period between the "Point of Exhaust Cut Off" and the "Point of Admission" at the same port.

To be clearly understood on the effects of "Exhaust Lap" and "Exhaust Clearance," take the case shown in Figure 15. If "Exhaust Lap" is added, the "Point of Release" would occur later and the "Point of Exhaust Cut Off" would occur earlier. If on the other hand "Exhaust Clearance" is given the "Point of Release" would occur earlier and the "Point of Exhaust Cut Off" would occur later.

Lead

As far as we have gone, the valve has been shown on the point of Admission, when the piston is about to commence its stroke. A port opening at this particular moment seems to be favored by the majority, if one can be guided by present day Locomotive Shop Practice. This amount of port opening, when piston is about to commence its stroke is called the "Lead" of the valve, see Figure 24.

Angular Advance

Figure 24, as compared with Figure 12, shows the Eccentric Sheave moved around the axle a little further to obtain the port opening called "Lead."

The angle the centre line of Eccentric Sheave was moved through to overcome the Steam Lap of the Valve, in Figure 12, added to the angle it is moved through to give Lead, is known as the "Angular Advance" of the Eccentric Sheave, see Angle "E," Figure 24.

If the length of rocker arms "A" and "B," Figure 24, are equal, then the Eccentric Sheave has to be moved around from the position shown in Figure 12 to that shown in Figure 24, so that the distance "C" is equal to the "Lead" "D", Figure 24.

Pre-Admission

With the last change made, move engine around until the valve is on the "Point of Admission" at the back steam port, see Figure 25. It will be noticed that the Piston has not yet completed its stroke. The distance the piston travels from this point to the end of its travel is called "Pre-Admission."

Lead Effects

Increase the "Lead" of the valve and "Pre-Admission" occurs earlier during the piston stroke.

Compare Figure 25 with Figure 12 where no "Lead" is given and the result shows that when "Lead" is given to the valve, the "Point of Admission" occurs earlier during the piston stroke.

Figure 26 shows the valve on the point of Cut Off at the back port, and when compared with Figure 14, proves a much shorter "Cut Off" in Figure 26, where "Lead" is given to the valve. This means that when "Lead" is given the Cut Off occurs earlier in the stroke of the piston, other conditions remaining the same.

If you compare Figure 27 with Figure 19, it will be seen that the valve opens to "Exhaust" in Figure 27, before the Piston has travelled as far as in the case shown in Figure 19. It follows when "Lead" is given to valve, or "Lead" is increased that release occurs earlier.

Again, if we follow the engine around as seen in Figure 28 to the "Point of Exhaust Cut Off," we find that it occurs earlier as compared with the case in Figure 23.

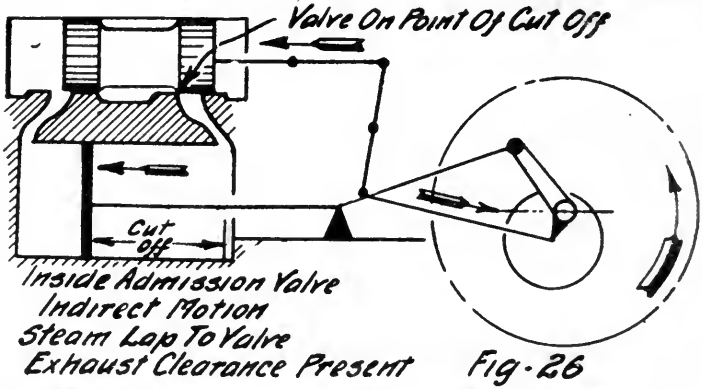
To sum up we find when "Lead" is given or increased that all valve events are hastened as compared with before the change. When "Lead" is decreased in any way the valve events are delayed as when compared with before the change.

"Lead On"

"Lead On" is an expression used when more lead is required.

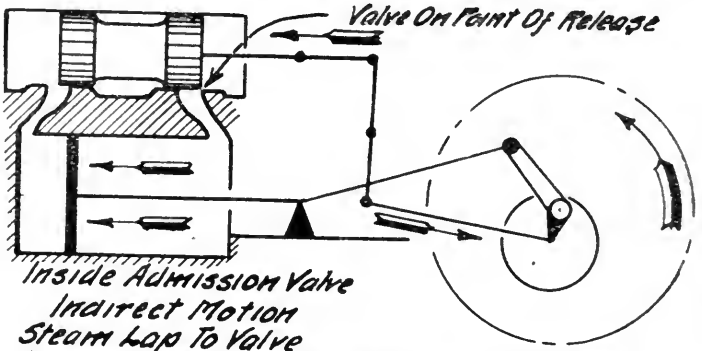
"Lead Off"

"Lead Off" is an expression used when a reduction in lead is required.



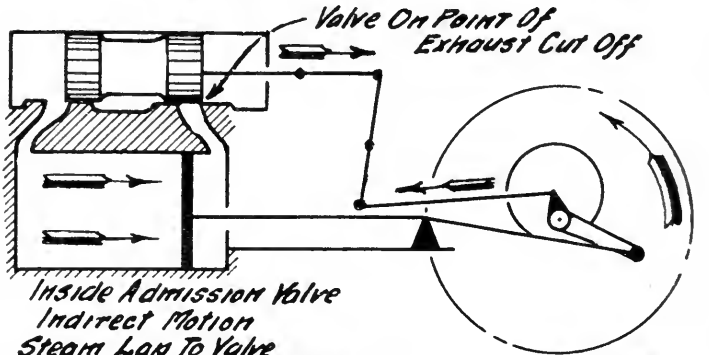
Inside Admission Valve
Indirect Motion
Steam Lap To Valve
Exhaust Clearance Present

Fig. 26



Inside Admission Valve
Indirect Motion
Steam Lap To Valve
Exhaust Clearance Present

Fig. 27



Inside Admission Valve
Indirect Motion
Steam Lap To Valve
Exhaust Clearance Present

Fig. 28

To Give Lead On

Move the Eccentric Sheave which actuates the valve, around the axle in the same direction as the engine operates.

To Take Lead Off

Move the Eccentric Sheave which actuates the valve, around the axle in the opposite direction to which the engine operates.

These last two rules apply in every case of a crude engine, also the Stevenson Link Motion, irrespective of the valve being an "Inside" or "Outside" Admission, whether the Rocker is "Direct" or "Indirect" or the relation of the Eccentric Sheave to the Main Pin.

To be more plainly understood, see Figure 29.

If the engine turns in the direction of arrow "A" then move sheave around axle in the direction shown by arrow "B" when "Lead On" is required. When "Lead Off" is required move the sheave around shaft in the direction indicated by arrow "C."

Note that when "Lead" is adjusted and "Eccentric Sheave" is properly keyed as in this, our case of a stationary engine, the "Cut Off" remains the same and is not variable except that which is occasioned by wear. "Cut Offs" gradually lengthen owing to wear of the valve rigging.

Positive Lead

When a valve has lead as shown in Figure 24, it is said to have "Positive Lead."

Line and Line

When a valve occurs as seen in Figure 12, it is said to be "Line and Line," i.e., "Lead," positive or negative is not present.

Negative or Blind Lead

When a valve occurs as shown in Figure 30, owing to wear or improper adjustment, i.e., the valve overlaps the steam port on the live steam side when piston is about to commence its stroke, it is said to be "Blind" or to have "Negative Lead."

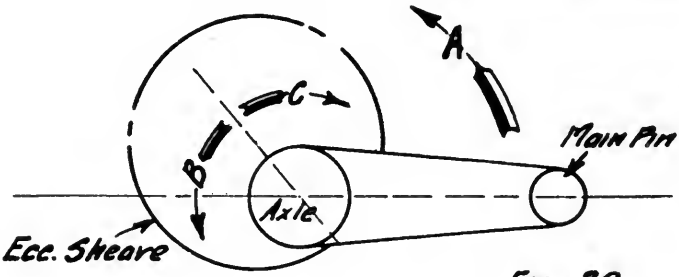


Fig - 29

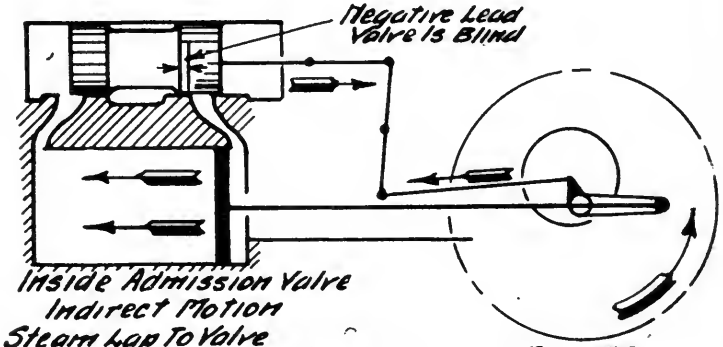


Fig - 30

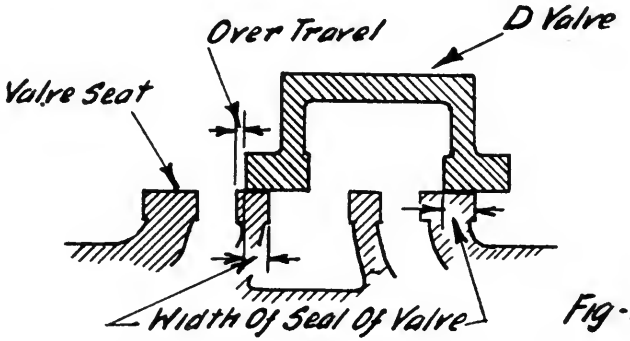


Fig - 31

Valve Travel

The length of a valve travel in this case, depends on the throw of the Eccentric Sheaves and the lengths of the Rocker Arms.

Where a Valve travel shall occur depends on the lengths of Eccentric Rods, Valve Rod and Valve Stem.

Bear in mind, whilst the length of the valve travel may be O.K. and the Eccentric Rod, etc., may be set O.K., to obtain equal travel to the valve on either side of the centre of valve seat, yet it is possible for the lead to be incorrect owing to incorrect setting of Eccentric Sheave.

The "Travel of a Valve" is the full distance through which any part of it travels in one direction during one stroke.

Overtravel

The "Overtravel" of a valve is the distance the live steam edge of valve moves beyond a full port opening, see Figure 31.

Seal of a Valve

The "Seal of a Valve" is the area or surface on the valve seat which the valve covers at the end of its travel to prevent live steam from escaping into the Exhaust Passages. See Fig. 31.

Tracing the Position of Eccentric Sheave approximately

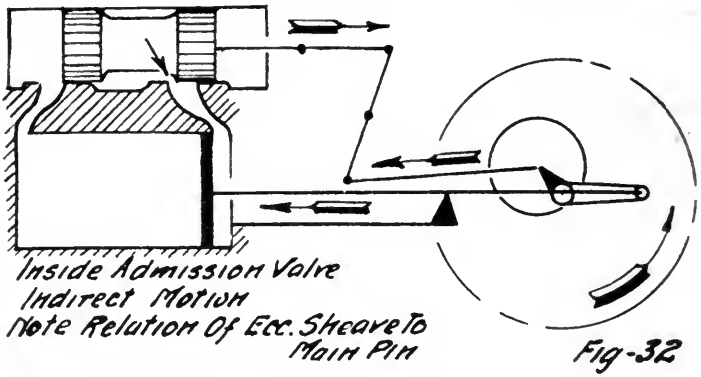
When the Valve is known to be "Inside" or "Outside" Admission and the Rocker known to be "Direct" or "Indirect," Figures 32, 33, 34 and 35 will show how same are laid out for each of the four cases.

Note the position of Eccentric Sheave, in Figure 32. It is the same as in Figure 35, it leads the Main Pin, and in Figure 33, the same as the case in Figure 34. it follows the Main Pin.

Piston Valve

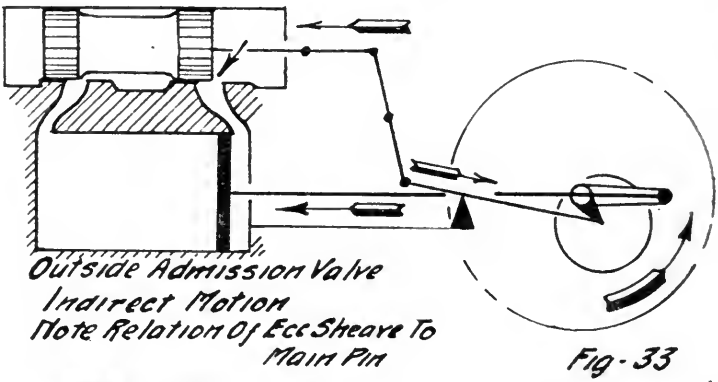
"Inside" Admission Piston Valves have been represented up to this time.

Piston Valves may be arranged for "Outside" Admission in which case "Steam Lap" would occur on the outer sides of Valve and "Exhaust Clearances" on the insides, see Figure 36.



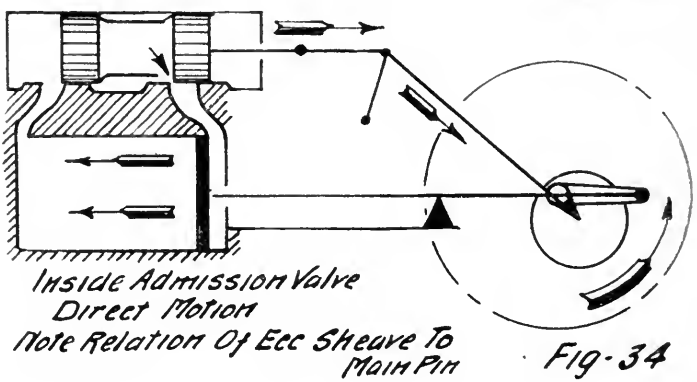
Inside Admission Valve
Indirect Motion
Note Relation Of Ecc. Sheave To
Main Pin

Fig-32



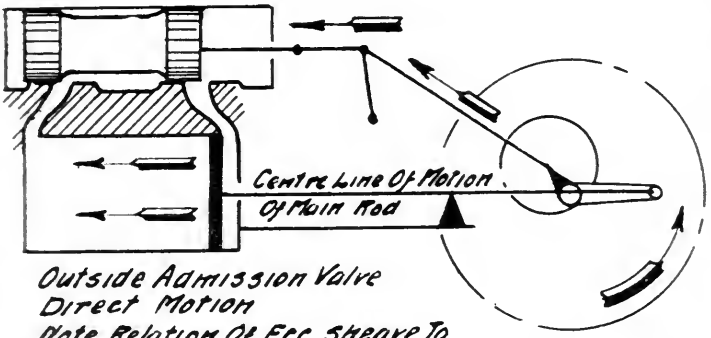
Outside Admission Valve
Indirect Motion
Note Relation Of Ecc Sheave To
Main Pin

Fig-33



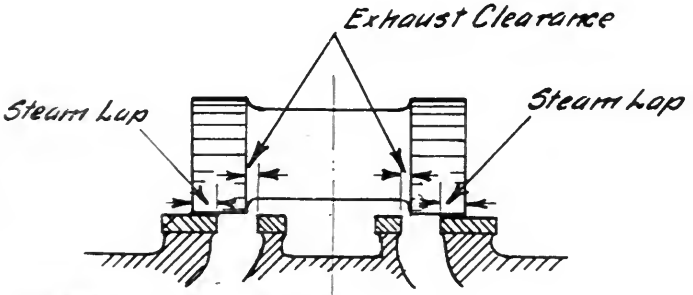
Inside Admission Valve
Direct Motion
Note Relation Of Ecc Sheave To
Main Pin

Fig-34



Outside Admission Valve
Direct Motion
Note Relation Of Ecc. Sheave To Main Pin

Fig - 35



Representing Outside
Admission Piston Valve

Fig - 36

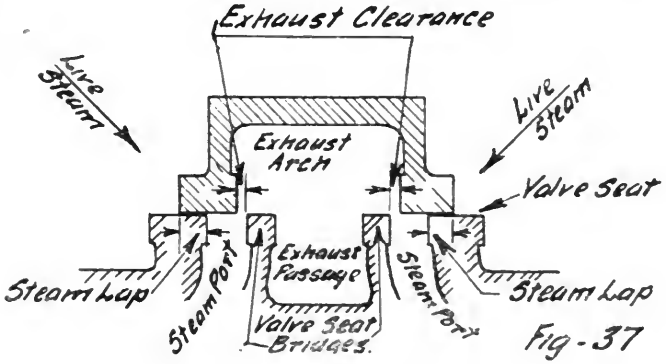


Fig - 37

"D" Valve

A "D" Valve is an "Outside Admission" Valve, see Figure 37.

Valve Movement

In the case of "Inside Admission" the valve moves in an opposite direction to that of the Piston when the latter is commencing its stroke, see Figure 32.

In the case of "Outside Admission," the valve moves in the same direction to that of the Piston, when the latter is commencing its stroke, see Figure 33.

Lost Motion

When an engine has been in service for a considerable period, the parts wear and cause what is known as "Lost Motion."

Turn an engine in one direction until the valve moves, then stop. Turn the engine the other way and the valve remains stationary for a short period whilst the Main Pin is moving to take up the slack, called "Lost Motion" in all the parts.

"Lost Motion" development is more pronounced in reversible than in one way engines.

Centre Line of Motion

When a rod during operation rises and falls an equal distance above and below a given line, that line is called the "Centre line of Motion" of the rod.

The "Centre Line of Motion" of a Main Rod is shown in Figure 35, of an Eccentric Rod in Figure 38. When same is horizontal no set is required in Rocker Arms.

Figure 39 shows the "Centre Line of Motion" of Eccentric Rod when depressed. Note the set necessary to the Lower Rocker Arm (exaggerated). The Centre Line of Lower Rocker Arm stands at right angles to the "Centre Line of Motion" of Eccentric Rod, when valve occurs in the centre of Valve Seat.

Figure 40 shows a case of the "Centre Line of Motion" of an Eccentric Rod, when same is elevated.

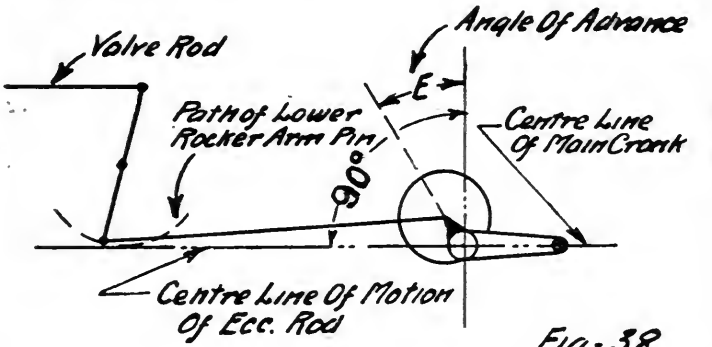


Fig - 38

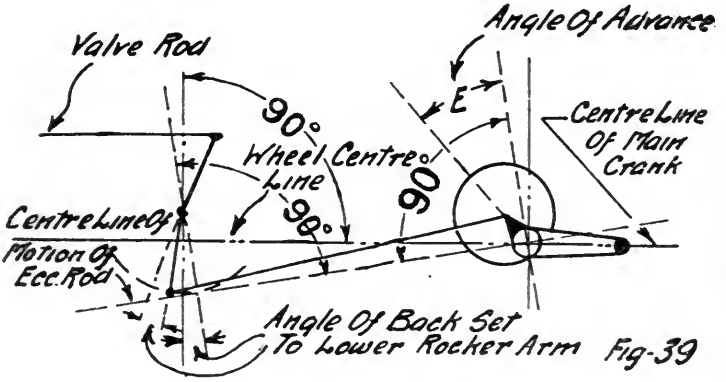


Fig-39

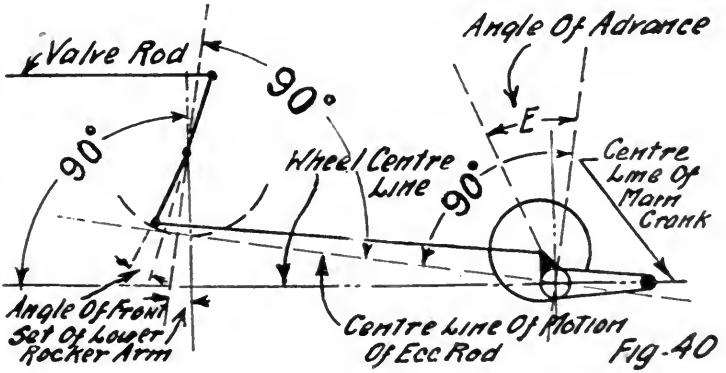


Fig-40

Laying Off "Angular Advance" of Eccentric

The "Angular Advance" of an Eccentric is always laid off from a straight line drawn at right angles to the Eccentric Rod "Centre line of Motion" and passing through the centre of axle.

See Figures 38, 39 and 40. Whilst the centre lines of Eccentric Sheaves lie at various angles, to centre line of main crank, note that the "Angular Advance," i.e., the Angle "E" remains the same.

Allen Ported Valve

If lead is given to the valve, "Pre-Admission" occurs. The greater the lead the better, if "Pre-Admission" can be kept small. Figure 41 shows the Allen Ported Valve which serves advantageously in this respect.

When this valve is open to the extent of the lead given to an ordinary "D" Valve, the "Allen" Port is also open the same amount. With this arrangement practically double the amount of lead is obtained with the same amount of "Pre-Admission" which would occur with the ordinary "D" Valve.

When setting for lead with an "Allen" Ported Valve, forget the "Allen" Port, work to specifications and do the same as you would in the case of an ordinary "D" Valve. (See Valve Setting later).

From Boiler to Atmosphere or Condenser

When steam throttle valve is opened, steam passes along the steam pipes to the valve chamber.

The valve when properly set, distributes and exhausts steam at the proper time.

Steam passes through the steam ports at each end respectively as follows:—

Admission occurs during the period from the point of Admission until the point of Cut Off is reached. The steam now being trapped and separated from the supply chamber exerts its power of expansion until the point of Release is reached.

The steam now escapes along the exhaust passages to the atmosphere or condenser as the case may be.

Exhaustion of steam continues during the period between the point of Release and the point of Exhaust Cut Off. The exhaust steam which remains in the cylinder is trapped and

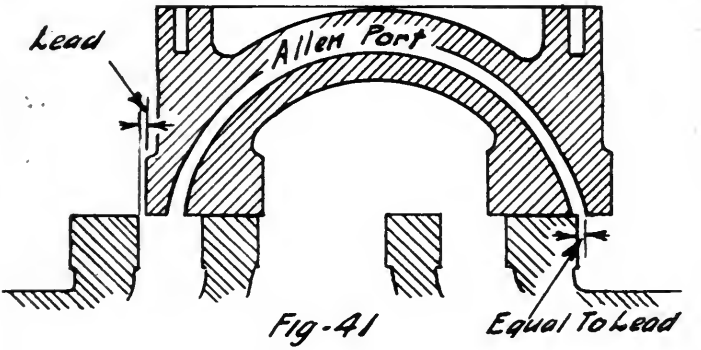


Fig-41

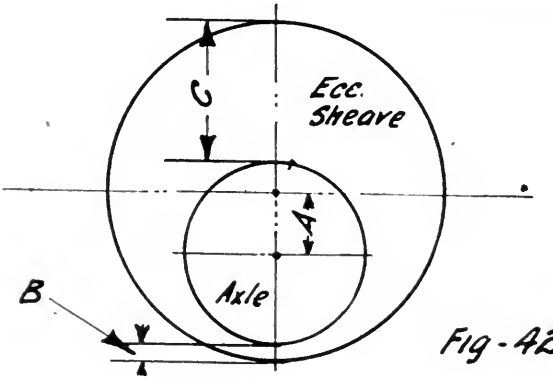


Fig-42

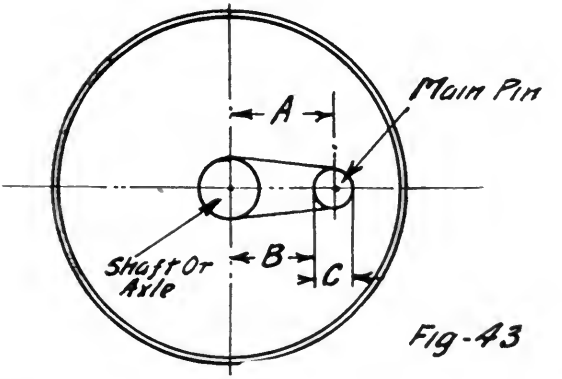


Fig-43

the further movement of the piston compresses same until the point of Admission is reached, which again allows of the entry of live boiler steam. This operation occurs at both ends of cylinder and is continuous whilst engine remains in service.

Throw of Eccentric Sheave

Figure 42 shows an Eccentric Sheave. The distance "A" is often called the "Throw" of the Eccentric and twice this amount the "Full Throw." The "Full Throw" of an Eccentric Sheave whether keyed to an axle or not, is quickly found by measuring radially with a scale the shortest distance "B," also the longest distance "C" and subtracting "B" from "C," i.e., if "C" equals 6½" and "B" equals 1½", then 6½" less 1½" gives 5" "Full Throw."

Throw of Main Pin

The "Throw" of the Crank Pin sometimes called the Main Pin is shown at "A" Figure 43. "The Full Throw" of Main Pin will be twice the distance "A." To measure up quickly, scale the distance "B" from centre of Shaft, to Main Pin, multilpy by 2 and add to same the diameter of Main Pin, i.e., if "B" equals 12" and "C" equals 6", then 12" multiplied by 2 and added to 6" gives 30" "Full Throw" of Main Pin.

The travel of a Piston during operation practically equals the "Full Throw" of Main Pin in all cases.

Dead Centres

Figure 44 shows the positions of a Main Pin which are known as Dead Centres, Front and Back.

A Main Pin is said to be on a Dead Centre when the centre lines of the Main Rod and Main Crank are in the same straight line when viewed from the side as seen in Figure 44, dotted lines.

The quarters and eighths are also shown in Figure 44.

Working Quarters

Note the position of piston, i.e., exactly in the centre of its stroke and the main pin, i.e., ahead of the top quarter. This position is known as the top working quarter. The position of the main pin when on the bottom working quarter is also shown.

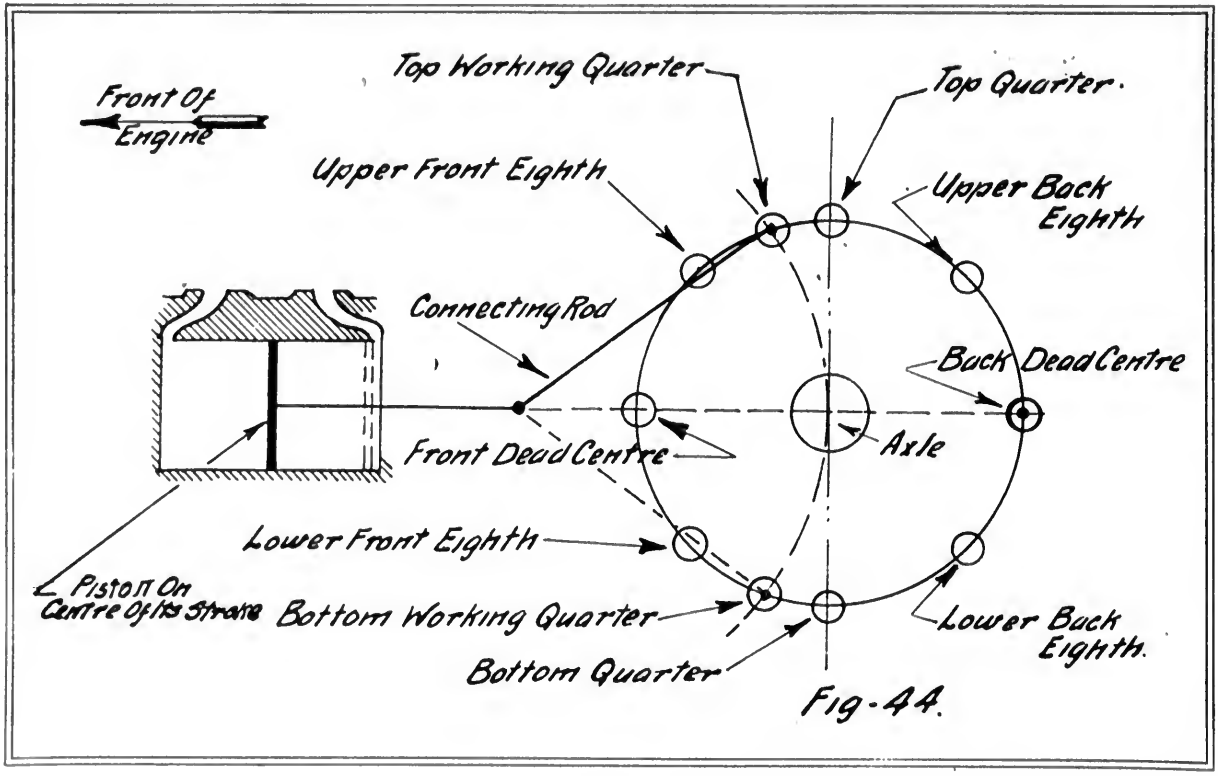

Front Of Engine
Top Working Quarter
Top Quarter.
Upper Front Eighth
Upper Back Eighth
Connecting Rod
Back Dead Centre
Front Dead Centre
Axle
Lower Front Eighth
Piston On Centre Of its Stroke
Bottom Working Quarter
Lower Back Eighth.
Bottom Quarter

Fig-44.

Chapter II.

STEVENSON LINK MOTION.

A Reversible Engine.

THE valve movements, etc., explained in the previous chapter are applicable more or less to reversible valve gears.

On a locomotive there are two reversible engines, one on either side, both being controlled with the same reversing gear and same steam throttle valve.

Inside and Outside Valve Motion.

A locomotive is said to carry "Inside Valve Motion," when the source of motion to the valve is set up from that part of the driving axle which lies between the Main Frames, also an "Outside Valve Motion," when the source of motion is set up on the outside of the Main Frames.

Stevenson Link Motion.

There are various reversible valve gears in service on Locomotives. Let us consider the Stevenson Link Motion.

Figure 45 shows a sketch of same with the parts named.

Figure 46 is a duplicate sketch of Figure 45.

Both sides of a locomotive are equipped similarly, except the reach rod and reverse lever which serves for both. Demonstration will be made from one side only for the time being.

Although one side only of locomotive is considered in Figure 46, look closely and you will note that there are practically two one-way engines, one eccentric sheave and eccentric rod for each, connected to the same common link, and the same valve, valve stem, valve rod and rocker is used in both cases.

An "Inside Admission Valve" and an "Indirect Rocker" is used in the example chosen.

It is easily seen in figure 46, if eccentric sheave "A" was connected by its Eccentric Rod to the Lower Rocker Arm Pin at "E" and the Eccentric Sheave "B" disregarded, that the engine would have to move in the direction "C," i.e., a forward engine would result, the same as shown in figure 24.

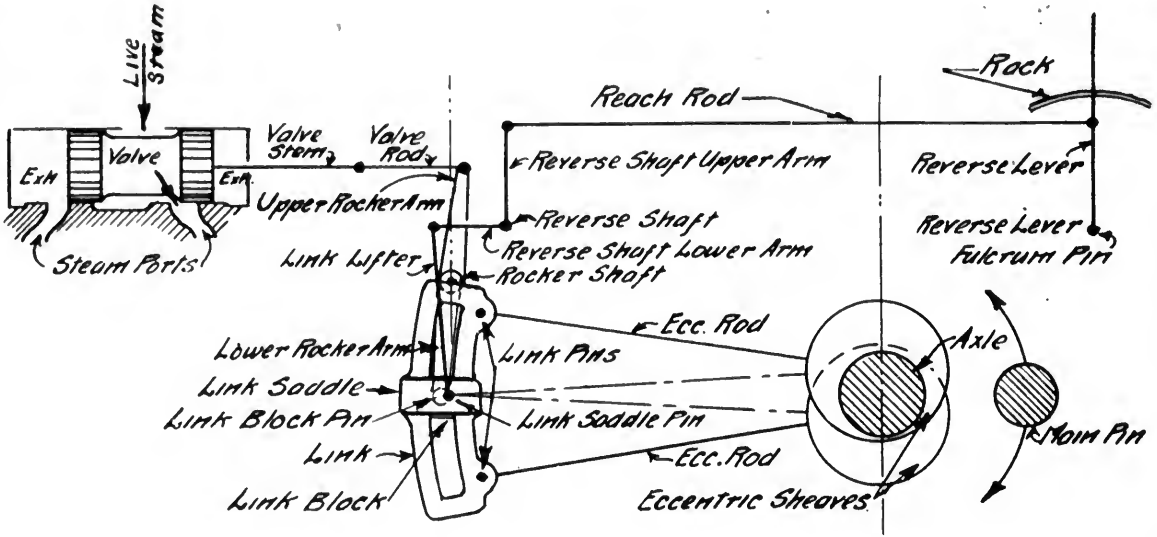


Fig - 45
Inside Admission Valve
Indirect Motion

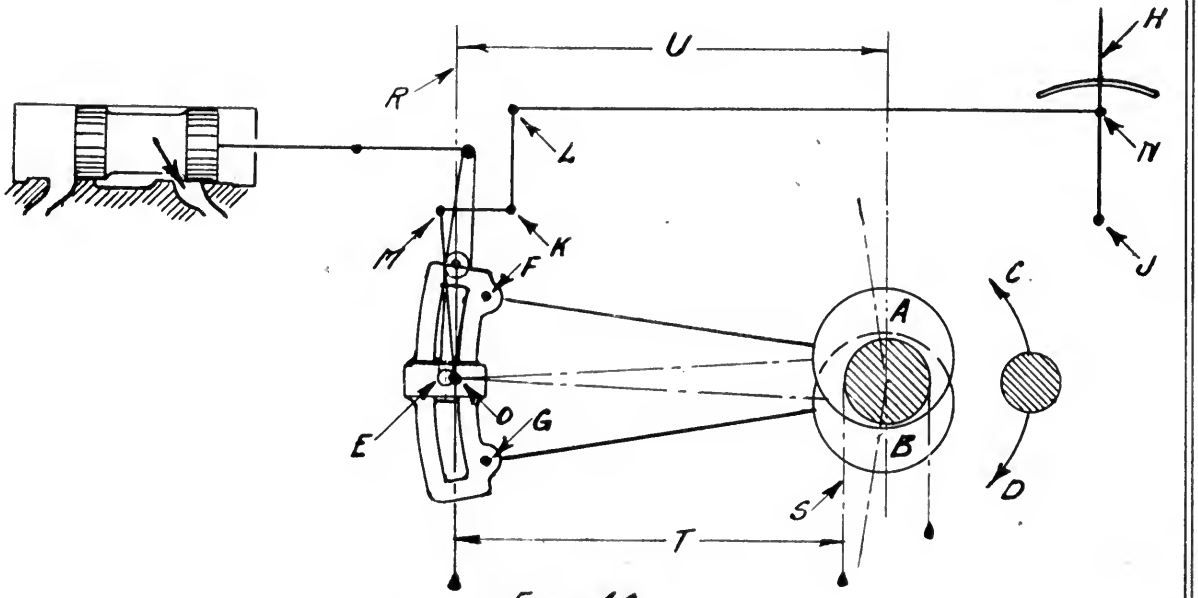


Fig - 46
Inside Admission Valve
Indirect Motion.

Again, if eccentric sheave "B" was connected by its eccentric rod to the pin at "E" and eccentric sheave "A" was disregarded, the engine would have to move in the direction "D," i.e., a backward engine would be the result.

In order to swing the eccentric sheave "A" or "B" into service at will, a link block was attached by means of a link block pin in a suitable manner to the lower rocker arm at "E." The link block is fitted to a shifting link at either end of which is connected the forked ends of the two eccentric rods respectively, see "F" and "G." The forward or go-ahead eccentric rod is generally connected at the top end of link. A means whereby to raise or lower the link is used. A reverse lever "H" with its fulcrum pin "J" at its lower end allows of a connection with the reach rod at "N." The other end of reach rod is connected to upper end of reverse shaft upper arm at the point "L." The reverse shaft occurs at "K" and carries two lower or lifting arms, one for each side of locomotive. One reverse shaft lifting arm is shown making a connection at the upper end of the link lifter at "M."

The lower end of link lifter connects with the link saddle pin shown at point "O." The link saddle is a means by which the link lifter is connected in a practical way with the link.

Forward Full Gear.

In the case of a one way engine, the eccentric rod is connected directly to the end of rocker arm.

This reversible gear having a link and link block, the nearest approach to obtaining the events during operation as before is to lower the link in the case of driving the engine forward, until the forked end or clevis of the forward eccentric rod is in line with the link block pin, see "A" Figure 47. The engine in this reverse lever position is said to be in "Forward Full Gear."

Front Corner Notch.

The reverse lever is said to be in the "Front Corner Notch" when reverse lever is in forward full gear.

Back Up Full Gear.

If the reverse lever is pulled backwards until the forked end of back up eccentric rod is in line with the link block pin, then the engine is said to be in "Back Up Full Gear."

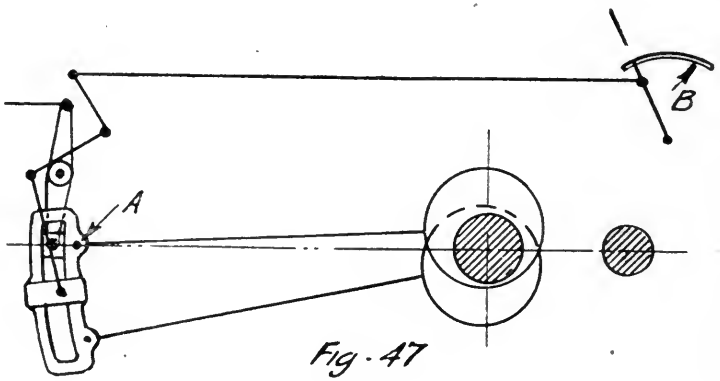


Fig. 47

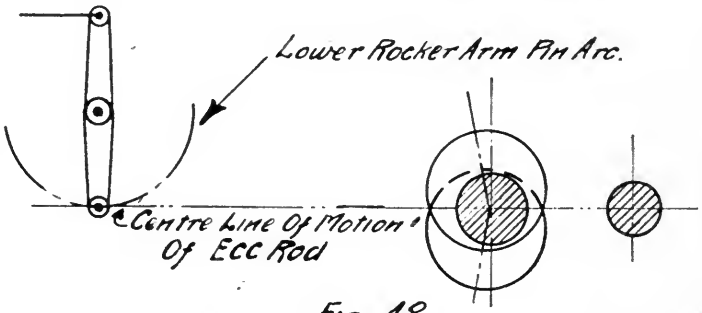


Fig. 48

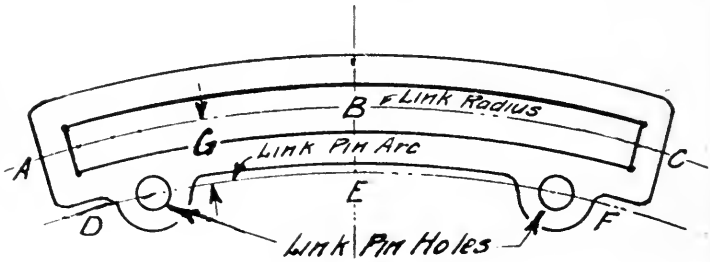


Fig. 49

Back Up Corner Notch.

The reverse lever is said to be in the "Back Up Corner Notch" when in back up full gear.

A toothed rack called a reverse lever rack, see "B" Figure 47, is provided so that with a suitable catch arrangement attached to reverse lever, same can be easily locked in any position required.

There are several kinds of reversing gears, operated by air, steam, wheel and screw, etc., as well as by a reverse lever.

If the case of a reverse lever is followed carefully, the others will be easily understood when met with.

Hooking Up.

When a reverse lever is pulled from a Corner Notch towards the centre notch of the rack, the movement is called "Hooking Up," or "Notching Up."

Midgear Notch.

When reverse lever is placed in a notch in the rack to obtain the shortest travel to a valve during operation when valve rigging is set O.K., it is said to be placed in the "Mid-Gear Notch." This notch is usually half-way between the forward and back up corner notches. Sometimes specifications cause same to occur a little nearer one than the other.

Dropping Down.

When a reverse lever is moved from the "Mid Gear Notch" towards the corner, the term "Dropping Down" is often applied.

Running Notch.

A switch engine generally operates with reverse lever in full gear, whereas in the case of a freight or passenger engine, the engineer hooks up the reverse lever to a notch where he gets best results as far as speed and economical fuel consumption is concerned. This notch is called the "Running Notch."

Centre Line of Motion.

The "Centre Line of Motion" of an eccentric rod in the case of "Stevenson Link Motion" is shown in Figure 48.

The application of Figures 39 and 40 can be made also to this reversible gear respecting the back set of lower rocker arms.

Link Radius.

Figure 49 shows a link in which the arc "A.B.C." is known as the "Link Radius."

Link Pin Arc.

The arc "D.E.F.," see Figure 49, which passes through the centres of the two link pins which connect the forked end of eccentric rods to the link is known as the "Link Pin Arc."

Slip of the Link.

When an engine, fitted with Stevenson Link Motion, is moved around, the link moves over the link block slightly when the reverse lever is near to the Mid Gear Notch, and becomes most pronounced in full gear. This movement of the link with respect to the link block is called the "Slip of the Link."

Over-Reaching.

When an engine of this kind is in operation the link moves through various angles. The eccentric rod pushes the link and the latter pushes the link block in order to move the valve. If the valve runs dry owing to neglected lubrication, etc., the valve is hard to move. The Eccentric Rod forces the link, especially at and near the end of the full gear valve travels, to slip a little more than when the valve moves easily. This extra slip of the link is called "Over-Reaching."

Out of Square.

When a valve rigging is not set properly, it is said to be "Out of Square."

Lame Engine.

When an uneven beat is heard as steam is exhausted from the smoke stack, one often hears the expression, she is "Lame."

Full Gear Valve Travel, or "Long Valve Travel."

The distance the valve travels during operation with the reverse lever in full gear notch is called the "Full Gear Valve Travel," or "Long Valve Travel."

Short Valve Travel.

The distance the valve travels with reverse lever in the "Mid Gear Notch" during operation is called the "Short Valve Travel."

Variable Valve Travels.

The valve travels being greatest when reverse lever is placed in the "Corner Notch," and least when placed in the "Mid Gear Notch," the decrease in valve travels when Hooking Up is easily seen, allowing of "Variable Valve Travels."

Length of Valve Travel Depends on :

(1) The Throw of the Eccentric Sheave.
(2) The Length of the Rocker Arms.
(3) The position of Reverse Lever in rack, or the position of Link Block in Link.

Lead Increase During Hook Up.

Figure 50 shows main pin on dead centre when lead occurs. To show clearly why lead increases during Hook Up, see the following :

If it were possible to have the centres of both eccentric sheaves at "A" Figure 50, and then the reverse lever hooked up, from full gear forward to Mid Gear, the Link Pin "B" of Eccentric Rod would sweep through the dotted Arc to the Point "C."

An Eccentric Sheave Centre must necessarily be out of the Centre of Driving Axle to render a source of motion to the valve. When reverse lever is placed in full forward gear and then it is hooked up to mid gear, the point "B," Figure 50, sweeps through an Arc, the centre of which is at "D" and arrives at the point "E."

Again the Link Pin Centre "K" having a radius, the centre of which is at "L," sweeps through an arc and arrives at point "J." The Link radius and the Link Pin Arc, see Figure 49, are parallel to each other and have a fixed relationship, except the slight difference caused by wear and tear of the parts during operation.

Hence it follows that as the Link Pin Centre "B," Figure 50, moves to "E" and Link Pin Centre "K" moves to "J" and the Link radius being advanced during the operation, until mid gear is reached, the link block pin is advanced an amount

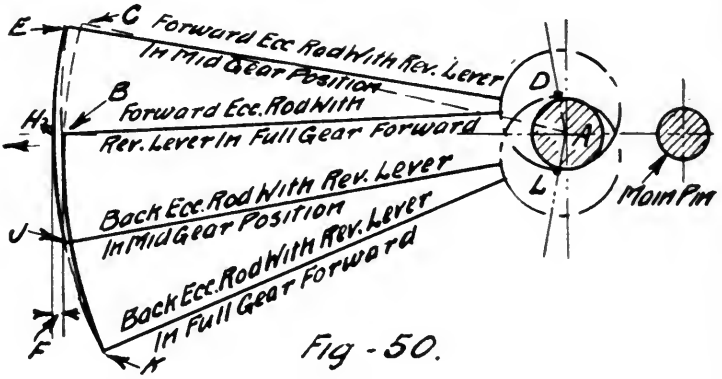


Fig - 50.

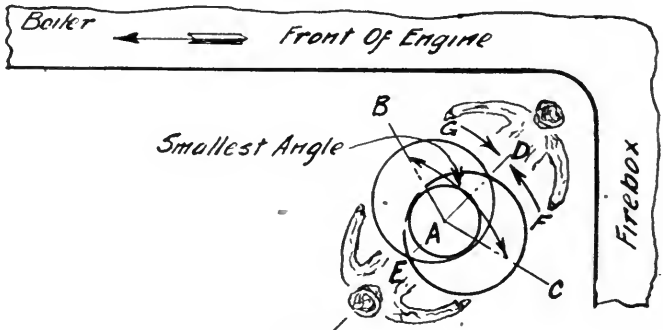


Fig - 51

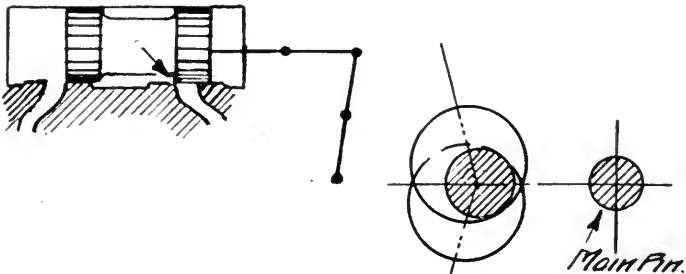


Fig - 52
Inside Admission Valve
Indirect Motion

equal to that shown at "F," i.e., the distance between "H" and "B." The movement of the Link Block Pin affects the lead of the valve through the medium of the Rocker, Valve Rod and Valve Stem.

Thus it is that Lead is increased as lever is hooked up from either of the full gear notches towards the centre of reverse lever rack.

Right and Left Lead Engines

When the main pin on the right hand side leads the main pin on the left hand side of an engine ninety degrees when running forward the locomotive is called a "Right Lead Engine."

When the left side main pin leads the right when running forward, the same amount, it is said to be a "Left Lead Engine."

Do not confuse the aforementioned with the "Lead of a Valve."

How to Quickly Determine which is the Go-ahead Eccentric

The following applies at any time particularly if about to connect the eccentric rods to the links in a dark round house. One does not have to trace for "Inside" or "Outside" admission valves, whether rockers are "Direct" or "Indirect" or the relation of eccentric sheaves to the main pin.

Figure 51 shows the position of axle and eccentric sheaves where by chance they have stopped.

A man going under an engine to put up a set of eccentric rods knows in which direction the front end of engine lies by the position of firebox.

The centre lines of the webs of the eccentric sheaves contain a smaller angle on one side see "BAC", Figure 51, than on the other, i.e., a man can reach the two webs on one side in the case of a heavy engine far easier in the position shown at "D" than when in the position shown at "E."

Just imagine yourself in the position "D" spanning the smallest angle between the webs. In order to bring "C" towards "B" it would have to be moved in the direction "F," which, when continued as a rotary motion, and applied to the driving wheel, same would turn in a forward direction. The forward eccentric sheave therefore is that which contains the centre web line "C."

Again, if Centre Line "B" is moved towards "C" same would move if continued as a rotary motion about the axle in a back up direction. The eccentric sheave with the centre line "B" is for the back up gear and is usually connected to the bottom of the link.

Always put your hands on the centre webs of eccentric sheaves so as to contain the small angle and bring your hands together. Continue the motion with your hands and the direction in which they move indicate the way in which the engine will move for the two sheaves handled respectively when brought in gear. The forward eccentric rod is generally connected to the top end of link.

The aforementioned stunt often saves expensive mistakes and leads one to a check up to see if driving wheels have been put in the right way in repair shop.

Tracing Approximately the Positions of Eccentric Sheaves

Figure 52 shows the positions of eccentric sheaves approximately, with respect to Main Pin with an engine having "Inside Admission Valves" and "Indirect Rockers."

Figure 53 shows the positions to be the same with "Outside Admission Valves" and "Direct Motion."

Figure 54 with "Inside Admission Valves" and "Direct Rockers" shows the approximate positions of eccentric sheaves to be the same as shown in Figure 55 where "Outside Admission Valves" and "Indirect Rockers" are represented.

Cylinder Centre Line

The centre lines of the cylinders on some engines are horizontal and very often lie three or four inches higher than the centres of driving wheel axles.

There are other cylinders inclined at a small angle to the horizontal.

In any case the picking up of dead centres properly for valve setting see next chapter, takes care of same, no matter how they occur from a valve setter's standpoint.

"Service Cut Offs"

These are cut offs taken when reverse lever is in the position where most of the regular work of the engine is done, i.e., in the case of a switch engine where most work is done with

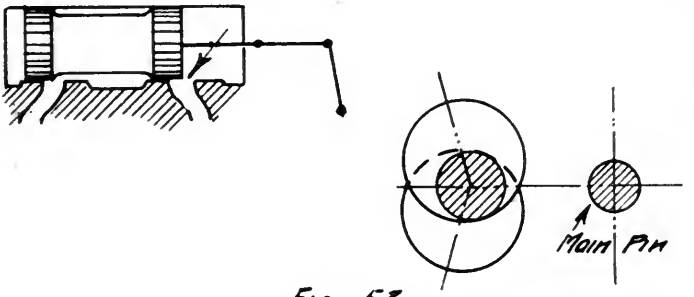


Fig. 53.
Outside Admission Valve
Direct Motion.

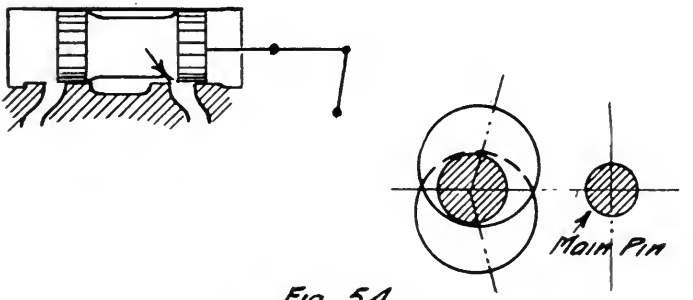


Fig. 54
Inside Admission Valve
Direct Motion

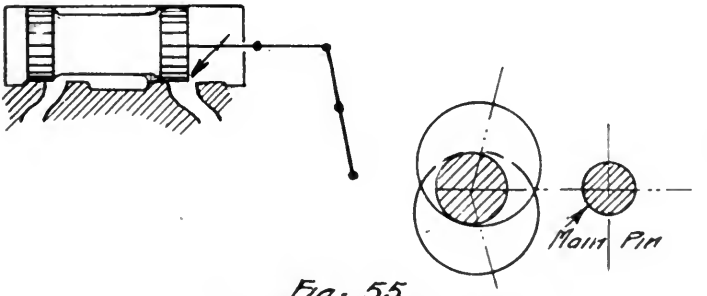


Fig. 55
Outside Admission Valve
Indirect Motion.

reverse lever in the "Full Gear Notch" the cut offs occur when the piston has travelled about seven-eighths of its stroke. In the case of a freight engine the service cut offs occur when piston has travelled about one-third of its stroke, and in the case of a passenger engine when about one-quarter of the piston stroke is reached.

These service cut offs are only approximate. It is for the engineer to use his judgment during operation as to how far he can "hook up" the lever to get the best results, compatible with speed and economy as the case warrants. It is worth noting that if an engine is squared up to "Service Cut Offs" she will be practically O.K. if "Hooked up" within a notch or two of same either way.

Chapter III.

STEVENSON LINK MOTION ASSEMBLY

THE power of a locomotive depends partly on the design of the valve gear.

The careful assembly and adjustment of the various parts of the valve gear however is most essential.

It is not the intention of the writer to describe how to fit up a valve gear in detail, yet a passing reference to one or two features of the work will fit in at this time.

Motion

To fit the various parts of a valve gear on an engine, complete, is referred to in shop terms as "Putting up Motion," or "Hanging the Motion."

A "Motion" Fitter generally hangs the motion on an engine. He does not put in the main valves as a rule.

The eccentric rods and straps are left down for the valve setter, also. Different rulings exist, however, in various shops.

When you are told to set the main valves on an engine, fitted with Stevenson Link Motion, make sure the "Motion" is hung properly, i.e., when main frames of engine are levelled see that the reverse shaft and rocker shafts are levelled and stand in a line square to the main frames with their respective bearing bolts tightened up.

Look over and feel out by movement of the reverse lever to see that the motion can be handled easily.

An improper set or unnecessary twist in a reach rod, reverse shaft arm, link hanger, etc., will cause a "TIGHT" reverse lever.

"Motion" improperly balanced will cause the reverse lever to handle harder in one direction than the other. Adjust the Motion balance spring if necessary.

Eccentric Straps

When putting up eccentric straps, see that same can be pulled around the eccentric sheave a complete revolution easily when strap bolts are tightened.

Experience has taught the policy of leaving 1/32" slack sidewise and 1/32" slack diametrically between the eccentric strap and eccentric sheave.

See that Eccentric Sheaves are securely fastened to driving axle.

Eccentric Rod-Setting

Try out each eccentric rod for twists and sets as follows:—

Bolt the back end of eccentric rod to its eccentric strap. Don't forget to tighten the nut with a spanner and avoid being fooled, see "A" Figure 56.

Lift the forked end of eccentric rod to touch the part of the link where same has to be connected. Work the forked end sidewise back and forth to see if same has equal side play on both sides of link during the movement, if not, measure the distances travelled by the fork as shown at "B" and "C," Figure 56. Take the short distance "B" from the long distance "C" and half the difference is the amount the forked end of eccentric rod has to be brought over by placing a set in the rod at the part marked "D." Before making any alteration, disconnect the eccentric rod at the eccentric strap and connect up the forked end to the link as shown at "A," Figure 57. Don't forget or neglect to put on Link Pin Nut and tighten it up with a spanner.

Now try out for side play as shown at "B," Figure 57, in a similar manner as before.

Note how far eccentric rod needs to be brought over. This has to be effected by putting a set in the eccentric rod at the point shown at "C," Figure 57.

Before putting a set in a rod, chalk carefully and scribe the outline of the rod on a plate or place a straightedge on the flat portion of the fork as at "A," Figure 58, and measure "B" Figure 58. After placing the set in at "C," check same by applying the rod to the scribed outline or by the use of the straightedge application again to see if O.K.

The other set can be made in a similar manner.

Get one set over the required amount before tackling the second one.

When two sets have to be made in one rod, make an allowance for the effect of one set on the other. This is found by

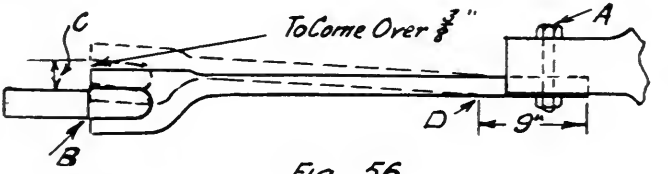
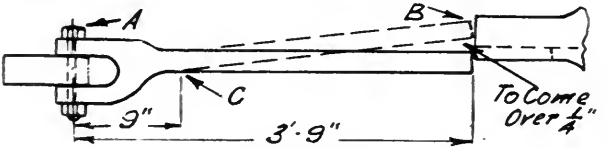


Fig - 56



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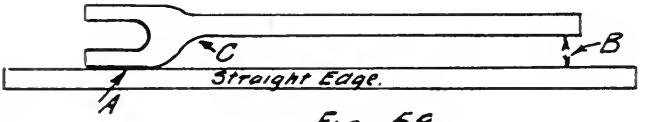

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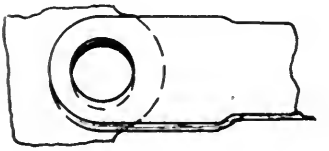

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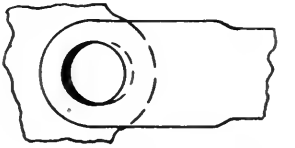

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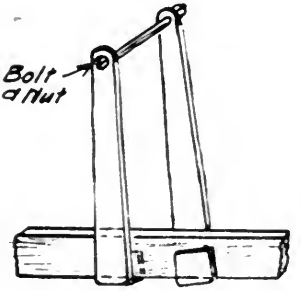


Fig - 61

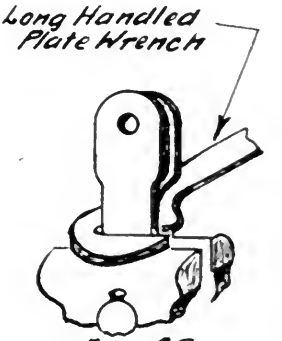


Fig - 62.

experience only. A close approximate setting can be figured for example:—

Take the Point "D," Figure 56, as 9″ from the back end of eccentric rod, the point "C," 9″ from the centre of fork end pin, see figure 57, and the length of eccentric rod from the centre of the fork end pin to the back end of eccentric rod as 3′-9″. Upon trial it is found that the back end of rod has to be brought over ¼″, see Figure 57, and the front end ⅜″, see Figure 56.

Make the bend at "C," Figure 57, to bring over the end "B," Figure 57, just the ¼″.

This set made at "C," Figure 57, has favored the fork end, i.e., "C" is 36″ from the back end "B" and 9″ from the front 'A."

Bringing over end "B" ¼″ means that end "A" has been brought over 1/16″ favorably in this our case, when fork end is disconnected and back end "B" is again connected.

The front end trial, see Figure 56, proved that the fork had to be brought over ⅜″ but having been favored 1/16″ the set put in at "D," Figure 56, has to be put in to bring the fork over 5/16″ only.

If a press is used to put the sets into a rod and same is operated by power, take a precautionary measure to reduce guess work to a minimum by adjustment of packing carefully under the rod before applying pressure.

Eccentric Rod Twisted

When putting up an eccentric rod after the sets are O.K., bolt the back end on the eccentric strap first and tighten the nuts.

Place the fork end on the link with a view to putting in the link pin.

A twist in the rod is easily noticed if present, see Figure 59, and the pin cannot be entered by hand easily.

Do not grind a finished link pin rather than remove a twist in a rod.

If the holes appear as shown in Figure 60, depend on it the set is incorrect.

A pair of twisters are generally supplied as a shop tool, see Figure 61.

Do not twist a rod when connected both ends. Disconnect the fork end at least. Remove the twist and try again.

One should be able to push a link pin in ⅛" of being home ready for tapping home with a hand hammer.

Sometimes a long handled twister is used with the rod in a strong vice, see Figure 62.

Bear in mind a man seldom gets fired for doing a good job. If in doubt, go to it, take the rod down and do the job right. Sets and twists in other rods can be handled in a similar manner to the foregoing.

After all sets are O.K. and twists removed, disconnect both back up eccentric rod fork ends and lower them out of the way of the links.

Blowing Through Steam Passages

Before putting in main valves it is the general practice to fill up the boiler with high pressure air, give a warning to your workmates to keep clear by blowing the whistle or by any commonly understood practice of the shop, then to open up the throttle valve and blow through the dry pipe, steam pipes and steam passages in cylinders to clear same of any foreign matter, dirt, etc.

It is understood that the Steam Pipes, etc., are all assembled on the locomotive to allow of same.

Again pass your hand and arm after blowing through, into the passages, using a piece of wire to find out if any piece of foreign matter such as a bolt or stud, etc., has become lodged in such a way that blowing through could not rid the passage of same, yet at a later date, vibration might work same down into the steam chest and wreck the valve.

Remove any such foreign material if present from the cavities.

Some workers think it a better policy to put valves into valve chamber, put on the steam chest covers and then blow through, moving each valve before each shot of air to open each steam port in turn.

The safest practice is to consider and use both, i.e., blowing through before and after valves are put in.

In any case blowing through the cylinders occurs before pistons are put in.

Shop Report

Before valves are put in make sure all information is gained as required by the shop you are working in.

Take the case of an "Inside Admission" Piston Valve.

Take the distance "A," Figure 63, with an adjustable gauge as shown, i.e., the distance between the inside edges of the two steam ports when bushings are in their proper position in steam chest. This distance must be O. K. to blue print requirements.

Now measure the distance "B," Figure 64, subtract it from "A" Figure 63, and divide the answer by two (2).

The steam lap of the valve is the answer, providing that the steam ports and valve dimensions are as called for by blue print.

Measure the distance "C," Figure 63, and take from it the distance "D," Figure 64, and divide by two (2).

The result is the exhaust clearance of the valve.

If the distance "D," Figure 64, is greater than the distance "C," Figure 63, take "C" from "D," divide by 2 and the result is the exhaust lap of the valve. Exhaust lap is seldom used, generally "Exhaust Clearance" or "Exhaust Line and Line."

In the case of an "Outside Admission" Valve, "A" Figure 63, taken from "B," Figure 64, and divided by 2 would give the Exhaust Clearance, also "C," Figure 63, taken from "D," Figure 64, and divided by 2 would give the steam lap.

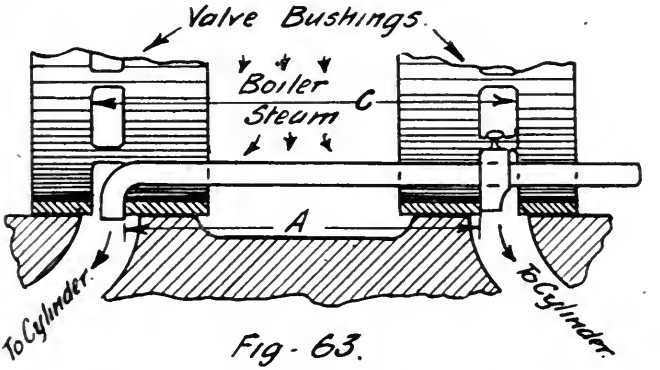
The steam lap and exhaust clearance of a "D" Valve can be measured in the same way as a piston valve.

Do not oil the valves at this time, put the valves in, put on the steam chest covers, and blow through before oiling. Dust, etc., during blowing through collects on valve if oil is present same being unnecessary and detrimental.

In addition to steam lap and exhaust clearance being required for shop report, the type of valve, whether "Inside" or "Outside" Admission, "Allen" ported or if a "D" Valve, the thickness of valve lip also the thickness of valve seat are generally called for, see Figure 65. These items can be readily taken and noted before valves are put in.

Valve Stem Fits

A piston valve stem is rigidly secured to its piston valve, whereas a "D" Valve stem is welded to a Buckle which fits over its valve. The latter fit is an easy one without slack inasmuch that when the projecting piece "A," Figure 65, is machined down to proper length to keep the valve stem alignment during operation it should be possible for the other



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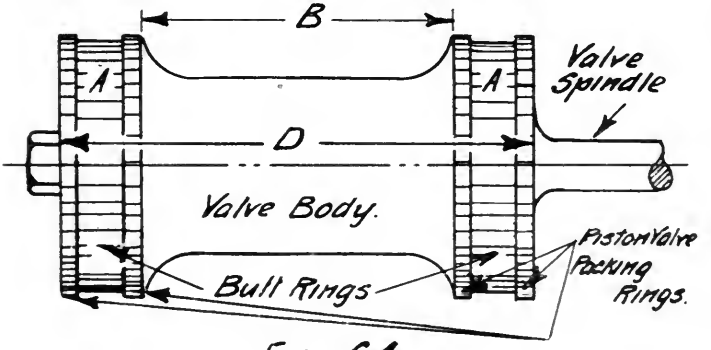

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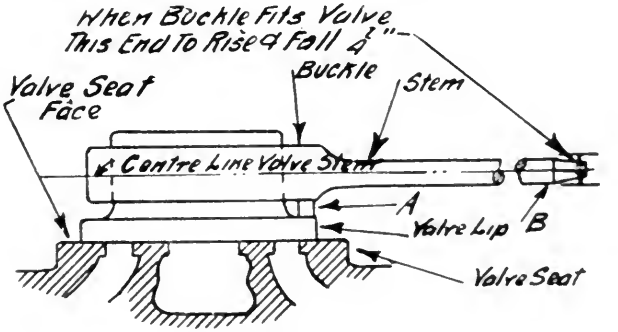
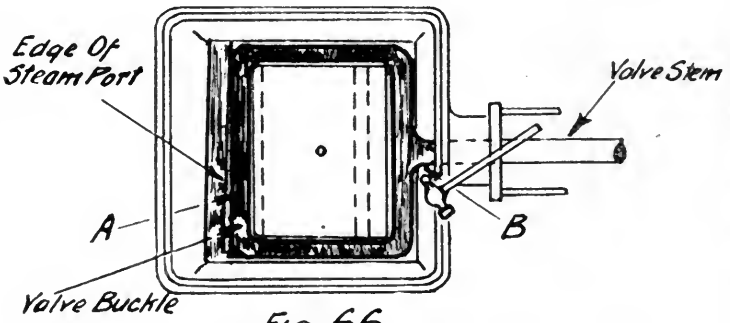


Fig. 65.



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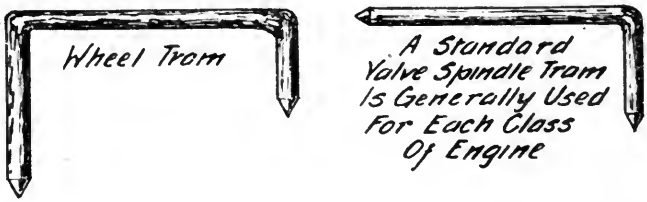

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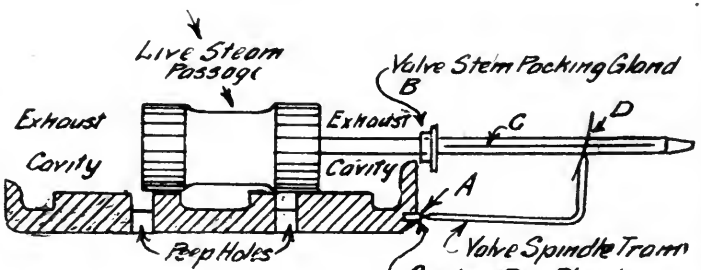


Fig-68
Arrangement Of Peep Holes
Looking Down From Top

end "B," Figure 65, when not connected to valve rod, to be moved ⅛" above and ⅛" below the centre line of valve stem travel.

Setting "D" Valve Stems

When a "D" Valve and its buckle with stem is placed on valve seat, set the outside edge of valve next to the outside edge of a steam port to see if they coincide. If they lie at a small angle to each other as shown at "A," Figure 66, apply a small forcing finger clamp as close to the root of the valve stem as possible and peen the latter with a hand hammer as shown at "B," Figure 66, until O.K. If buckle and valve also steam chest are machined properly, the aforementioned error will not occur.

Valve Bump Marks

After valves are put into steam chest properly, put on steam chest covers in the case of piston valves. If "D" Valves, leave them off for the time being. Pull the valves in turn towards the back end until they bump the steam chest or back steam chest cover as case may be.

This can be conveniently handled, connecting up the valve stem to the rocker arm by putting up the valve rods and using a bar for levering over.

Now take a suitable valve spindle tram, see Figure 67, long enough to reach from a fixed centre pop in the cylinder, see "A," Figure 68, to a location on the valve stem or valve rod, which ever is the most convenient to take a full gear valve travel reading, without having the latter if on the valve stem, enter the valve stem packing gland during valve setting. In other words when valve is on its back bumping point, the point of the tram intended to mark valve stem with should be seven or eight inches away from the nearest face of the valve stem packing gland, see "B," Figure 68.

Rub a little lampblack and oil on the valve stem or valve rod where reading is about to be taken, i.e., from where the aforementioned tram touches the stem to about 6" or 7", back from this point.

Use a box square and scribe a line along stem or on valve crosshead bracket if used parallel to the line of travel of the valve, see "C," Figure 68.

In a Locomotive Erecting Shop a standard length valve spindle tram is kept and checked periodically for each class of engine.

The fixed centre pop "A," Figure 68, is generally placed in a plug which has been screwed tight into cylinder to suit the trammelling of valve stem.

Take this tram, place properly in centre pop in plug and scribe a small arc to cut line on valve stem, see "D," Figure 68.

Push the valve ahead and lever backwards to the bumping point again. Try out the tram again to see if the first arc scribed is not false. If tram marks coincide on this second trial, put a small pop where the arc cuts the straight line and consider same as an indication of danger during valve setting if ever this pop comes within 1/16" of the tram point.

Push the valve to the front end, levering same until a bump is felt. Proceed to take the bump mark for the front end in the same way as just detailed for back end.

Full Gear Valve Travel

The approximate full gear valve travel can be found by adding twice the steam lap of the valve to twice the width of the live steam port in valve seat and to this add ⅛" for over-travel of the valve at each port.

The last item is mentioned as a guide to the uninformed when starting in to figure the distance a valve stem reading will take up on a valve stem.

Another way to figure full gear travel when the valves are in and covers are on, is to measure the full throw of the eccentric in inches and divide same by the length of the inner rocker arm in inches and multiply the result by the length of the outer rocker arm which connects with valve rod, in inches.

Piston Bump Marks

Put in the pistons and put up the front cylinder covers. Connect piston rods to crossheads properly being sure the piston glands, etc., are on piston rods. Drive the piston rod cotters home.

Pull back by levering the crossheads until a fairly good back bump is felt. Be sure crosshead is not fouling a bracket, etc. Scribe a line on guide bar as shown at "A," Figure 69, by means of a short straight edge and scriber.

Pull the crosshead ahead six inches and haul back with a bar until you can feel the piston really bumping the back cylinder head. Put up straightedge to see if the first mark

taken is not false. If same coincides with straightedge at this second trial, centre pop same and consider it a danger mark as far as crosshead travels are concerned.

Go ahead, pull crosshead to the front end and obtain the front bump mark "B," Figure 69, in the same way as described for the back end.

The distance between these two piston bump marks both scribed from the same end of crosshead is generally about ¾" longer than the full throw of main pin.

Clearance

To arrive at a clear understanding on "Clearance," suppose the main rods are connected, also the valve rigging including eccentric rods.

Move engine around in full gear and the long valve travel occurs.

The distance between the valve at the extreme end of its travel and its bumping point at that end is understood by the shop man as Clearance of the valve. This occurs and applies at each end of steam chest.

The distance between the piston at the extreme end of its travel and its bumping point at that end is understood by the shop man as the "Clearance" of the piston. This occurs and applies at each end of the cylinder.

This must not be mistaken for or confused with the "Exhaust Clearance" of a valve previously explained.

Again it must not be confused with the interpretation of clearance as understood by some outside the province of the shop valve setting, i.e., the volume of the cavities lying between the face of the valve seat or the face of the bushings where valve fits and the face of the piston when the extreme end of its travel is reached. This latter item in no way applies to valve setting, it is simply explained to prevent misunderstanding.

Let us get back to an assembled motion with the two back up eccentric rods disconnected and dropped clear of the links.

Port Marks

To take port marks in the case of a "D" Valve the steam chest cover is left off.

Peep hole plugs are provided in the case of piston valves which allow a direct view of the steam ports from the outside,

when plugs are taken out and a flash light or a piece of lighted candle on the end of a piece of wire is used.

In any case jar valve over carefully until it is seen that it is on the "Point of Admission." Exercise great care in this respect and if in doubt move valve to open the port and come again as the saying goes to the "Point of Admission," edge to edge.

If perchance an Outside Admission "D" Valve is used and there is a slight angle between the edge of the valve and the edge of the port, say 1/32" to nothing in the full length of the port, some workers split the difference and set edge to edge in the centre of the transverse length of the port.

Once the valve is set O.K. to point of Admission, say at the front port, scribe a small arc with the valve spindle tram to intersect the line "C," Figure 68, and shown more clearly at "A," Figure 70.

Jar the valve over to the point of Admission at the back port and scribe a small arc to intersect the straight line as shown at "B," Figure 70.

Find the centre of the distance between arcs "A" and "B" on the line "C" at the point "D" with a pair of sharp needle pointed dividers.

Many valve setters would figure on "A" and "B," Figure 70, as being port marks and "D" as the centre of same. This is not so in all cases.

In the case of a "D" Valve which is "Outside Admission" or with an "Outside Admission Piston Valve," the slight increase in the length of Valve stem due to a difference in expansions is compensated more or less by the volume the piston rod occupies at the back end of cylinder and the aforementioned points "A" and "B" are O.K. as port marks.

In the case of an "Inside Admission Valve," the small amount of valve stem expansion over and above that of the cylinder, coupled with an allowance to compensate for piston rod volume warrants an allowance of 1/32" bare in the case of non-superheater engines, and 1/32" in the case of superheater engines.

This allowance is made only on engines having "Inside Admission Valves" in the following way.

Take Figure 70. Consider a superheater engine for example. Instead of centre popping the centre Point "D" make a fine centre pop on the straight line "C" 1/32" ahead of the point

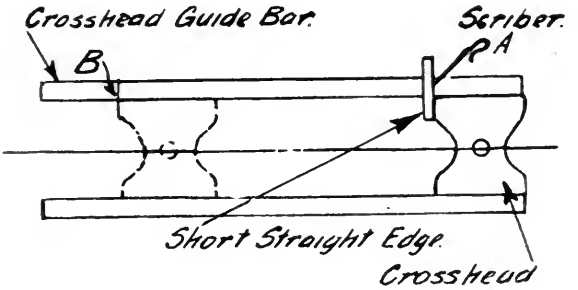


Fig. 69

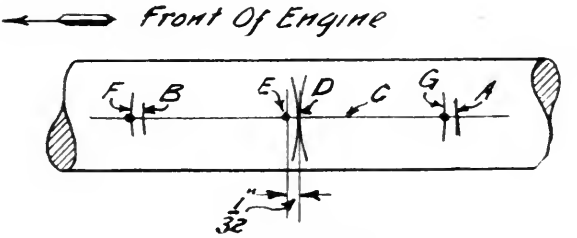


Fig. 70

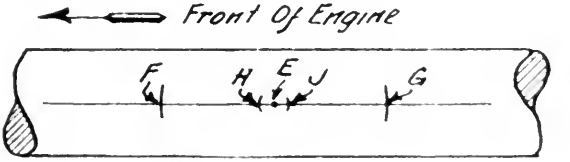


Fig. 71

"D." See "E," Figure 70. Set dividers to the lap of the valve which is exactly half of the distance between "A" and "B." With "E" as centre scribe two small arcs "F" and "G" and centre pop finely where the arcs cut the straight line "C." You may now forget all effects of valve stem expansion and piston rod volume during the remainder of the valve setting.

Consider "F" and "G" as Port Marks which will indicate when the points of Admission and Points of Cut Off for both steam ports occur respectively, as they reach the valve spindle tram later.

To allow of a clear understanding on Port Marks, take it for granted that the "Inside Admission Valve" in our example has $\frac{1}{8}''$ exhaust clearance.

With the dividers set to exactly $\frac{1}{8}''$ radius and with the point "E" as centre scribe two arcs "H" and "J." See Figure 71. Centre pop where arcs cut the straight line.

When centre popping, make a clean pop in the right spot with one centre and not make a couple of stabs at it, and get a result which cannot be relied on for accuracy. Be careful when drawing a pop mark over and get one centre in a pop mark, not two.

The centre pops at "H" and "J," Figure 71, are port marks which will indicate the points of release and the points of exhaust cut off for both ports respectively as they reach the tram point.

It is well to remember that the release and exhaust cut off port marks are not taken or used in shop practice during valve setting unless a record of the pre-release and exhaust cut offs are called for particularly.

In order to make this still clearer, suppose the valve has $\frac{1}{8}''$ exhaust lap, then the pops on the arcs "H" and "J," Figure 71, scribed with the dividers set to a radius of $\frac{1}{8}''$ equal to the exhaust lap, would still serve to indicate as they reach the tram point, when the point of release and the point of exhaust cut offs occur respectively.

If the valve has no exhaust clearance and no exhaust lap then the centre pop "E," Figure 71 when it just reaches the tram point would indicate the point of release to one port and the point of exhaust cut off to the other or vice versa dependent upon the direction in which the valve is moving at the time.

Care must be exercised when using port marks. To help out in this respect, take it for granted that the valve motion, etc., is assembled with main rods up and the engine is being moved around.

The following tables together with the sketches will give an idea of that which occurs as the port marks reach the tram point respectively.

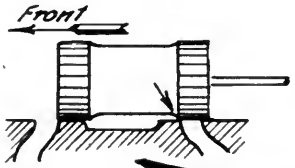
Under Tram Point	Direction in which Valve Moves	Inside or Outside Admission Valve	Point of Admission or Point of Cut Off	Occurs at Front or Back Port
Pt. Mk. F Fig. 72	L Fig. 72	Inside	Pt. of Admission	Back Port
" F " 72	K " 72	"	" Cut Off	" "
" G " 72	L " 72	"	" "	Front "
" G " 72	K " 72	"	" Admission	" "
" F " 73	L " 73	Outside	" "	" "
" F " 73	K " 73	"	" Cut Off	" "
" G " 73	L " 73	"	" "	Back "
" G " 73	K " 73	"	" Admission	" "

Under Tram Point	Exhaust Clearance or Exhaust Lap	Direction in which Valve Moves	Inside or Outside Admission Valve	Point of Release or Point of Cut Off	Occurs at Front or Back Port
Pt. Mk. H Fig. 74	Exhaust Clearance	L Fig. 74	Inside	Ex. Cut Off	Back Port
" H " 74	" "	K " 74	"	Release	" "
" J " 74	" "	L " 74	"	"	Front "
" J " 74	" "	K " 74	"	Ex. Cut Off	" "
" H " 75	" Lap	L " 75	"	Release	" "
" H " 75	" "	K " 75	"	Ex. Cut Off	" "
" J " 75	" "	L " 75	"	" "	Back "
" J " 75	" "	K " 75	"	Release	" "
" H " 76	" Clearance	L " 76	Outside	Ex. Cut. Off	Front "
" H " 76	" "	K " 76	"	Release	" "
" J " 76	" "	L " 76	"	"	Back "
" J " 76	" "	K " 76	"	Ex. Cut Off	" "
" H " 77	" Lap	L " 77	"	Release	" "
" H " 77	" "	K " 77	"	Ex. Cut Off	" "
" J " 77	" "	L " 77	"	" "	Front "
" J " 77	" "	K " 77	"	Release	" "

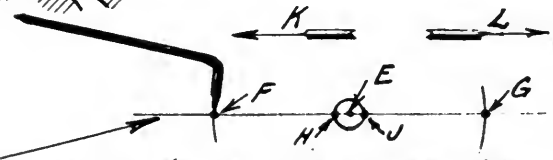
The beginner with a little concentration will easily follow the tables and sketches relative to exhaust port marks. Having done so, the case where a valve has no "Exhaust Clearance" nor "Exhaust Lap," just "Exhaust Line and Line" will also be followed easily.

Protection of Valve Stem Readings

When port marks have been taken, bend a piece of thin sheet iron or tin around the valve stem and long enough to cover the readings to protect them on both sides of engine.

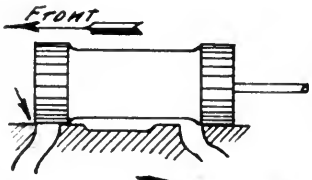


Inside Admission Valve On Point Of Admission Or Point Of Cut Off At Back Port.

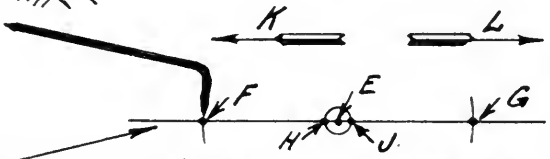


Port Marks As They Occur When Valve Is In Position Above Shown.

Fig - 72

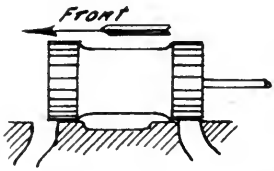


Outside Admission Valve On Point Of Admission Or Point Of Cut Off At Front Port

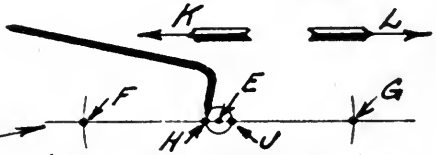


Port Marks As They Occur When Valve Is In Position Above Shown

Fig - 73.

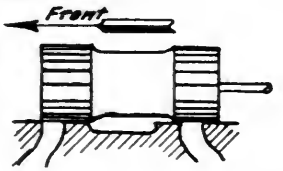


Inside Admission Valve Exhaust Clearance Given Valve On Point Of Release Or Exhoust Cut Off At Back Port.

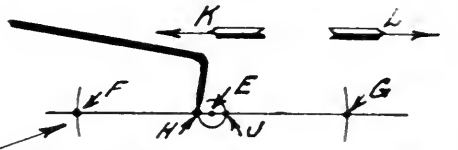


Port Marks As They Occur When Valve Is In Position Above Shown.

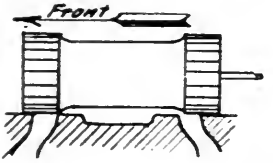
Fig - 74



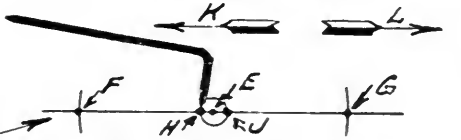
Inside Admission Valve
Exhaust Lap Present
Valve On Point Of Release
Or Exhaust Cut Off At
Front Port



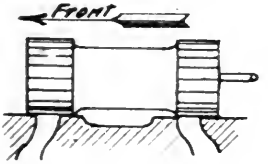
Port Marks As They Occur When
Valve Is In Position Above Shown.
Fig - 75



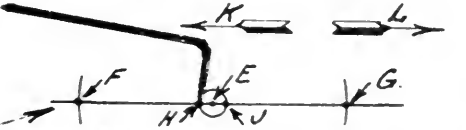
Outside Admission Valve
Exhaust Clearance Given
Valve On Point Of Release
Or Point Of Exhaust Cut Off
At Front Port.



Port Marks As They Occur When
Valve Is In Position Above Shown
Fig - 76.



Outside Admission Valve
Exhaust Lap Present
Valve On Point Of Release
Or Exhaust Cut Off At
Back Port.



Port Marks As They Occur When
Valve Is In Position Above Shown.
Fig - 77

When working on one valve stem have the other one covered. Both readings to be covered during a temporary absence. It "gets your goat" when a shop mate slides down from off a run board and wipes out your readings with his overalls. Safety First often saves a dispute.

When taking port marks in the case of a "D" Valve, and the buckle is somewhat slack, take up the slack whilst so doing by inserting a thin steel wedge between the buckle and the valve as at "A," Figure 78, whilst taking the front port mark and as at "B," Figure 79, when taking the back port mark.

When port marks are obtained the steam chest covers, etc., can be placed, and steam chest finished up properly in the case of a "D" Valve.

Valve Rod Length.

To determine valve rod lengths. Place the valve practically on the centre of valve seat, i.e., jar the valve until centre pop "E" reaches the valve spindle tram point when placed properly, see Figure 80.

If the valve travels horizontally then a plumb line should pass through the centre of the upper or outer rocker arm pin "A," and the centre of the rocker shaft "B," Figure 80. A plumb line is quickly made up with a piece of fine twine and a nut tied at one end of same.

If the valve rod is of such a length as to push the upper rocker arm out of plumb, or in any case "out of square" to the centre line of the travel of the valve stem, have valve rod altered in length to effect same, when the aforementioned centre pop "E," Figure 80, coincides with the tram point. Make this change right at this time, and DO NOT ALTER IT LATER.

Boiler Expansion Allowance.

A locomotive boiler increases in length as steam pressure is raised in it, when compared with the same boiler cold, the amount depending upon the length of the barrel, firebox, etc.

A reach rod has a certain definite length and once this is arranged, should never be altered.

Take an example where two or three inches of air space at least lies between the reach rod and the side of the firebox, also the reverse lever fulcrum pin and the reverse lever rack,

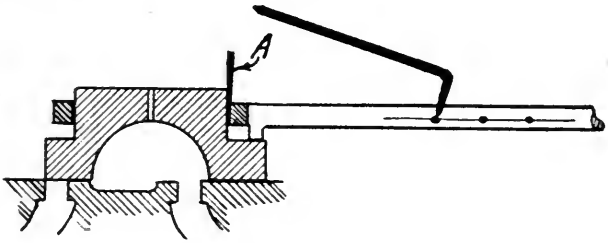


Fig - 78

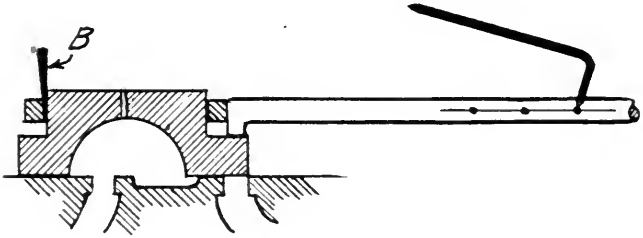


Fig - 79

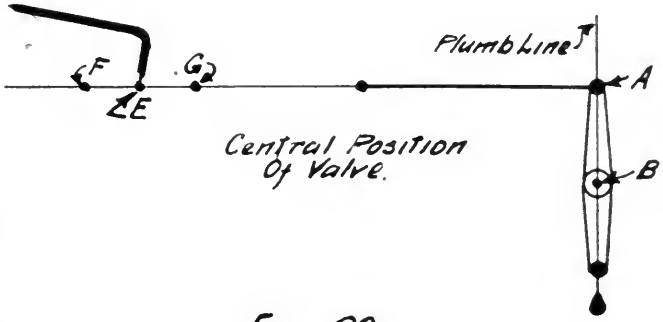


Fig - 80

being in no way connected to the side of the boiler. The reverse lever in mid gear notch should stand plumb, when main frames are levelled, see "A," Figure 81.

When reverse lever is placed in the middle notch of its rack and the reach rod is connected, its length, "B" Figure 81, should be such that it will hold the upper arm of rocker shaft plumb as shown at "C" Figure 81.

Let us assume that boilers are cold during valve setting operations. In the case where the reverse lever rack, also the reverse lever fulcrum pin, are both directly connected to side of firebox, the reverse lever when placed in mid gear notch should stand plumb, see "A" Figure 82, but the centre of the reach rod pin connecting with the upper arm of reverse shaft must occur ahead of the plumb line passing through the centre of reverse shaft a distance equal to the amount affected by boiler expansion, see "B" Figure 82.

A third case shows where the reverse lever fulcrum pin is attached to main frame of engine or to a bracket attached to same, see "A" Figure 83, and yet the reverse lever rack is fastened to side of firebox or to the run board, which is in turn attached to side of firebox and affected by boiler expansion, see "B" Figure 83.

In the cases shown in Figures 81 and 82 the reverse lever is plumb when placed in the mid gear notch, whereas in this case the allowance for boiler expansion is made at the rack, when erected, inasmuch that the mid gear notch is arranged ahead of the plumb line which passes through the centre of the fulcrum pin "A" Figure 83, the distance being equal to "C" Figure 83, which is equal to boiler expansion effect, and has in turn a proportionate effect on reach rod as shown at "D" Figure 83.

The reach rod pin centre, see "E" Figure 83, should occur ahead of the plumb line "F" Figure 83, a distance "G" equal to "D" Figure 83, when reverse lever is in mid gear notch and boiler is cold.

One can almost hear the inquiry. How much do you allow for boiler expansion ?

There is so much guesswork in this respect that one is forced to reply that the only way to gain the proper information owing to the various arrangements of reverse levers and connections is to take one of each class of engine in turn and pursue the following course.

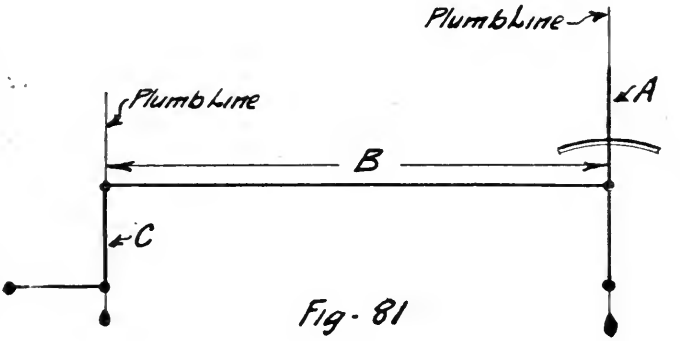


Fig - 81

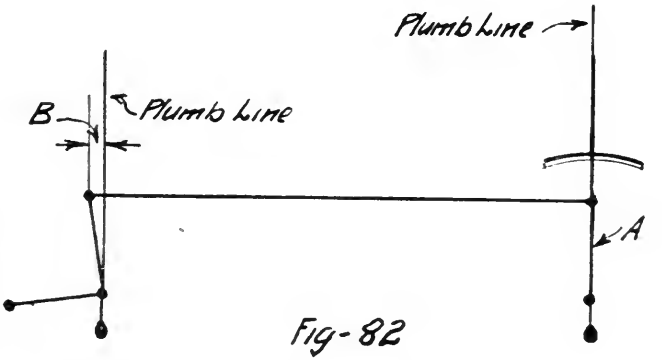


Fig - 82

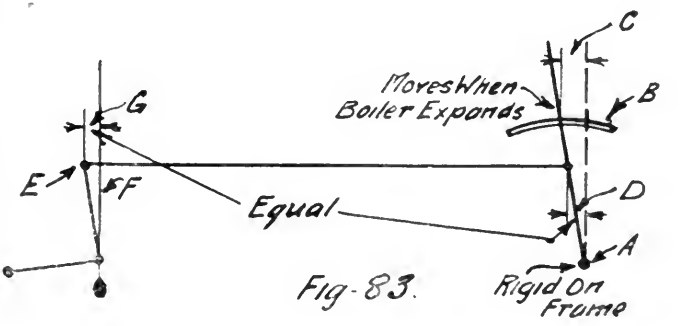


Fig - 83.

When boiler is cold take a suitable tram made up to suit the class of engine on which the check is to be made, and from a centre pop "D" Figure 84, made on a rigid portion of the engine, such as a main frame, which is not affected by boiler expansion, scribe an arc on the reach rod as at "A" Figure 84, the reverse lever being in the mid gear notch. Scribe a short straight line on reach rod see "B.C." Figure 84, parallel to the centre line of reach rod. This is done when you know that there will be no changes on an engine, i.e., in the case of a boiler having a wash out, same would be a good time to commence as aforementioned.

When boiler washout is completed and engine is ready for the road with maximum boiler pressure raised, DO NOT attempt to complete your job. Wait until the engine has shunted around or run say four or five miles or more, and then put one point of the aforementioned tram in pop "D" and scribe another arc, when reverse lever is in mid gear notch.

The distance between the Arcs "A" and "E" along the straight line "B.C" Figure 84, is the actual effect on reach rod owing to boiler expansion.

If air reservoirs, etc., are in the way on certain engines, find a rigid spot not affected by boiler expansion, and following the principle of the aforementioned, any old shaped tram may be used if suitably rigid for the aforementioned purpose.

Records of Boiler Expansions.

Shop records will probably show the boiler expansions and their effects on reach rods, etc., for all classes of engines repaired in that shop, for the ready reference of a valve setter.

Do not try to obtain boiler expansion proper in a back shop, where a boiler steam test, you may think, would serve the purpose, you get unreliable results if you try it.

Adjustable Reach Rods.

Many reach rods to-day are adjustable for length, in which case proceed as follows :—

Adjust the length of reach rod so that upper reverse shaft arm is plumb as shown at "B.C" Figure 85, when reverse lever is in mid gear notch. If boiler expansion affects the reach rod, adjust the length of the latter to allow for the former after valve setting, as shown at "A" Figure 85.

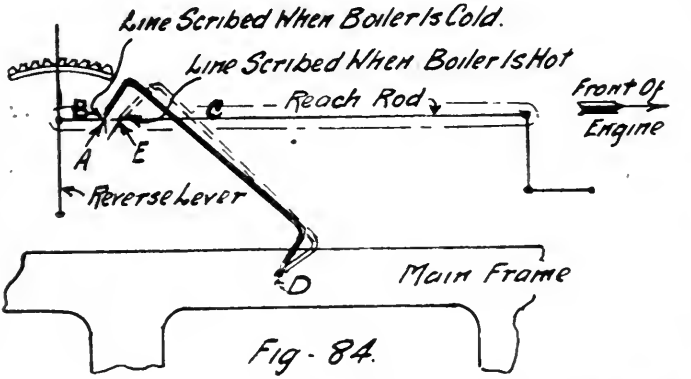


Fig - 84.

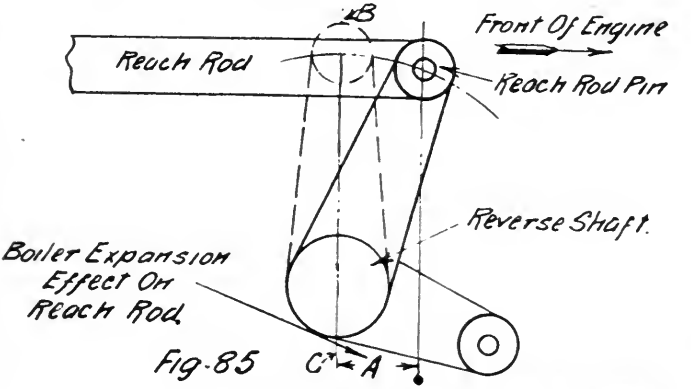


Fig-85

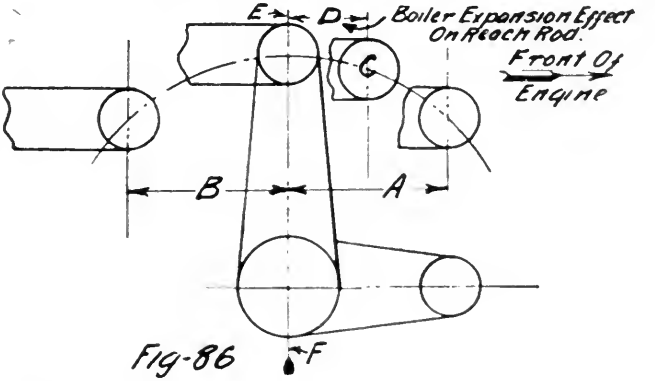


Fig-86

Non-Adjustable Reach Rod.

In the case of a non-adjustable reach rod take note of the following :—

No matter whether boiler expansion affects the reach rod or not, or whether the shop conditions at the time allow for an actual reach rod length change before valve setting or not, one can go ahead with the valve setting after measuring for actual reach rod length alteration, and the amount of alteration in length figuratively speaking for valve setting purposes.

Actual Reach Rod Length Change to be Affected.

Case. 1. Where boiler expansion DOES NOT affect reach rod.

Place reverse lever in mid gear notch. Drop a plumb line through centre of end of reversing shaft and measure the distance as shown at "A" or "B" Figure 86, as case requires. This is the actual change required.

Case 2. Where boiler expansion DOES affect reach rod.

"D" Figure 86, shows the allowance made for this boiler expansion effect and varies with the length of boilers used.

Place reverse lever in mid gear notch. Drop a plumb line through the centre of the end of reversing shaft and measure the distance as shown at "A" or "B" Figure 86, as case requires.

The actual change to be made in the length of the reach rod by the blacksmith equals the distance "A" less the distance "D" shortening, or the distance "B" added to the distance "D" lengthening. In this case the front end reach rod pin has to be brought to the position shown at "C" Figure 86 by actual change.

Figurative Change to Reach Rod Length for Valve Setting.

In all cases whether reach rod is affected by boiler expansion or not, measure the distance "A" or "B" Figure 86, and use same to guide you in making allowances on lead and valve travels during valve setting. See details in later chapter.

Chapter IV.

STEVENSON LINK MOTION VALVE SETTING DETAILS

Rollers Under

WHEN a worker gets detailed to put the rollers under the main driving wheels ready for valve setting, there is a whole lot more importance attached to the job than the casual observer might imagine. Some think it only a question of jacking up the engine to take the weight off the springs, pulling up the rollers to raise the wheels high enough to block the spring rigging and then letting down the wheels so that they turn easily, even if the tyres of the drivers just clear the rails 1/16″ of an inch.

One has to consider the height of the main drivers with respect to the main frames.

When an engine is placed on the road for service the boiler carries her load of water, whereas in the shop more often than not during valve setting, there is none in the boiler.

Start in by levelling main frames with the use of jacks at each end of engine.

Figure 87 shows a set of rollers in common use to-day, the long threaded rods serving to pull the rollers closer together, thereby raising the wheels.

Put the rollers under and pull up the nuts on the threaded rods equally until both driving boxes are the same distance from the top rails of main frames on both sides of the engine. The distance between the top of driving boxes and top rails to be about ¾″ less at this time than the distance called for on blue print.

Block your spring rigging to prevent the return of the springs over the main drivers and lower the latter by slacking the nuts on long rods thus opening out the rollers until wheels and incidentally the axle boxes are the correct distance from the main frames as shown on blue print or within ¼″ of same either way. The centre of axle, however, to be kept parallel to the top level of main frames.

The wheels must turn freely and must also be equidistant sidewise from axle boxes, i.e., the side play between the hubs of the wheels and the axle boxes must be equal on both sides.

Set wheels and rollers over if necessary when the weight is off same. Once set properly the wheels seldom work over during Valve Setting.

Again there must be no jamb of a wedge to hold an axle box off its journal. At this time make sure that the binders or guard stays which brace the shoe and wedge horns together for the main drivers, now set up on the rollers, have their bolts and studs with nuts properly tightened.

Driver Wedges

Slack down the axle box wedges, see that axle boxes are properly seated on their journals, give the wheels one revolution with the air motor and if they turn freely, set up both main driver wedges, using a monkey wrench or spanner about 9" long to pull up on the nuts of wedge bolts as tight as you can pull alone, then pull each wedge down 1/8" and lock wedge bolt nuts.

The Shoes and Wedges having already been fitted before engine is wheeled allows of a fine adjustment of wedges in this manner.

Main Rods

Put up main rods and see that brasses are a good fit on crank pin and crosshead pin respectively. Adjust the wedges or drive the cotters home properly as case may be in the main rods.

Minor Details

See that valve rod cotters are properly driven home and minor detai.s such as rocker arm pins, etc., are placed and nuts pulled up properly.

See that Link Saddles are tight. Other similar details of the motion should be checked up and if O.K. connect up the two back up eccentric rods to the two links respectively.

Finding Dead Centres with use of Main Rods

Dead Centres are taken in Valve Setting in order to obtain valve stem readings which readily presents an idea of the full gear lead on the engine.

All four dead centres are generally laid off on the right main driving wheel tyre. This gives a benefit to valve setters inasmuch that as a man is picking up dead centres, he has

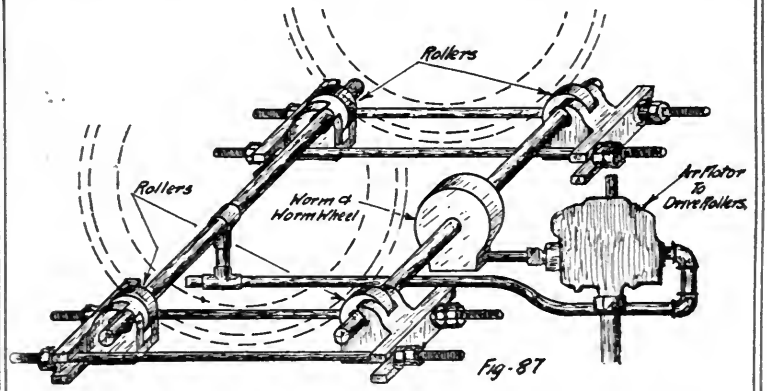


Fig. 87

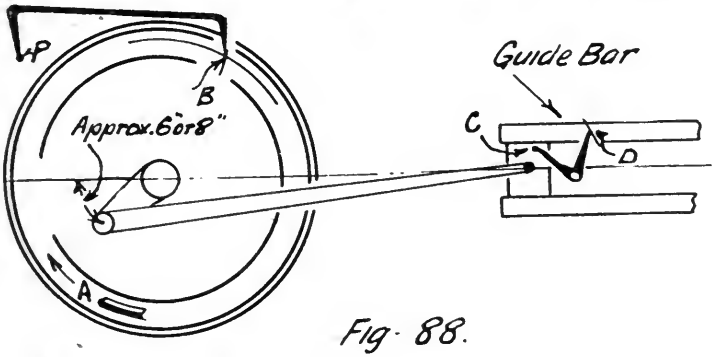


Fig. 88.

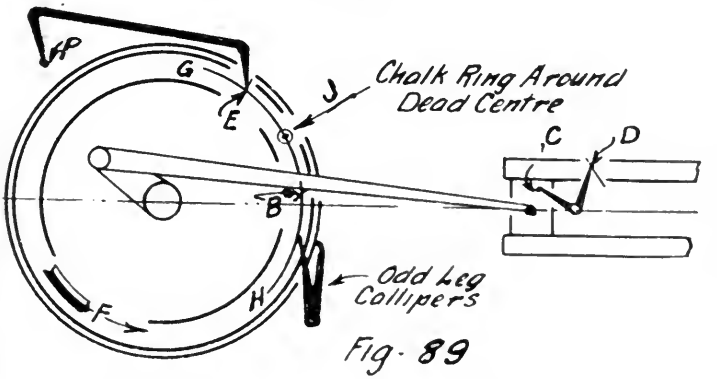


Fig. 89

a better opportunity to keep an eye on anybody attempting to or actually moving reverse lever from the proper notch in its rack without notifying the valve setter. Movement of a reverse lever will often cause a false reading to be taken. The position of a reverse lever in its rack does not matter when finding dead centres. It is, however, of great importance to have the reverse lever in the corner notches when catching dead centres to take lead lines.

To find a dead centre turn the drivers around to take up any possible slack in main rod. Continue to turn wheels until a main pin reaches approximately 6″ or 8″ from a dead centre as far as can be judged by the eye. See Figure 88. Stop the rollers and with a conveniently bent wheel tram see Figure 67, one point of which is placed in a centre pop made on the side of the frame or from any suitable fixed point, see "P," Figure 88, scribe an arc with other point of tram on the side of the tyre of the right main driving wheel as shown at "B." Now take a pair of dividers set conveniently say to 4″ and from a centre pop placed in crosshead as shown at "C," scribe an arc on guide bar as shown at "D." If there is over 1/32″ side play in crosshead, insert packing to reduce same whilst taking dead centres.

Now continue to turn rollers so that main pin approaches and passes the dead centre. Whilst this movement is going on in direction "A" Figure 88, keep one point of dividers in the pop "C" in the same manner as before until the other point of dividers passes a couple of inches by the previously scribed arc "D" on the guide bar. Reverse the rollers to turn the wheels in the direction shown by arrow "F," Figure 89, and stop when the free point of dividers just reaches "D," i.e., an arc can be scribed to just coincide with arc "D," see Figure 89.

Place the wheel tram point in the fixed pop "P" and scribe another arc on the same side of the tyre see "E," Figure 89. With a pair of oddleg calipers set, say to 1½″, scribe an arc "G.H. Figure 89, parallel to the outside circumference of rim and long enough to pass through both arcs "B" and "E," Figure 89. On the arc "G.H." find the central point "J" between points of intersection of the arcs "B" and "E." Centre pop the point "J," make a chalk mark around same and mark it for the dead centre it represents to avoid any possible mistakes. The Pops at "B" and "E" are generally

hammered out at this time. The other three dead centres can be found in a similar manner on the right driving wheel. The right back dead centre is chalked "R.B." and the right front "R.F." etc.

Finding Dead Centres with use of Tram

In the event of dead centres being required to be found and the main rods are not delivered, the former can be obtained with a tram of suitable length.

In Figure 90, is seen a crosshead pulled back until same is at the back end of crosshead travel or actually at the back bump mark. A fine straight line "A.B." is scribed on crosshead so that same passes through the centre of crosshead wrist pin and if produced would pass through the centre of driver axle when viewed from the side as shown in Figure 90.

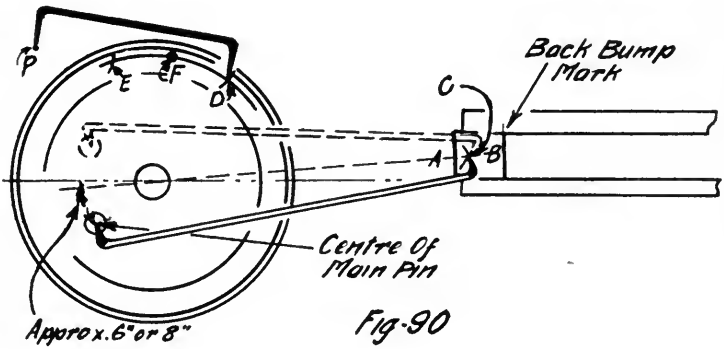
Turn main drivers around until the centre of main pin reaches a point approximately 6″ or 8″ from the dead centre see Figure 90. Stop the wheels.

Place one point of tram in the CENTRE of main pin and with other tram point scribe a line to cut the line "A.B." at "C." Place one point of wheel tram in a fixed centre pop as shown at "P," Figure 90, and with the other tram point scribe an arc on the rim of the wheel as seen at "D." Turn the wheels so that main pin approaches and passes the dead centre, meanwhile holding the tram in the centre of main pin. Watch the front tram point carefully and just as it coincides with the point "C" stop wheels.

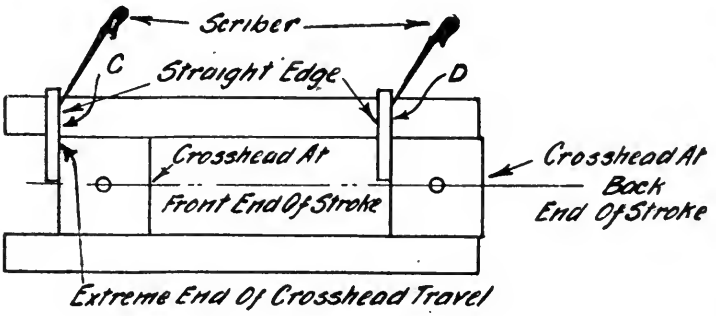
From the pop "P" using the wheel tram scribe another arc on the rim of the wheel as seen at "E," Figure 90.

With a pair of oddleg calipers set to about 1½″ scribe a line parallel to the outer circumference of the tyre to cut the two arcs scribed with the wheel tram at "D" and "E."

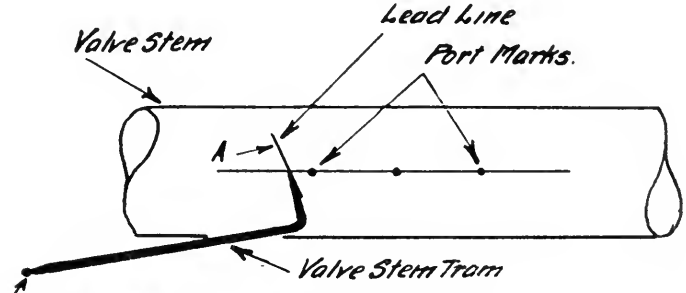
Find the centre between "D" and "E" at the point "F" on the line parallel to the rim and centre pop same. Hammer out the pops at "D" and "E" and chalk a ring around pop "F." If the wheels are turned around until the pop "F" just coincides with one point of wheel tram, when other point is placed in the fixed pop "P" and then are stopped, you have caught a dead centre. Exercise care in finding and catching a dead centre, it pays..



Fig·90



Fig·91



Fig·92

All dead centres can be found with the use of a tram in this manner and can be relied upon, providing the crosshead is moved to the end of its travel, the position of which corresponds with the dead centre being found and the line through centre of crosshead wrist pin being scribed to suit each dead centre as before detailed in the example just given.

Crosshead Travels and Clearance

In the event of finding dead centres with main rods up, the piston travel and piston clearance at both ends of cylinders can be found at the same time by scribing a line with the use of a short straight-edge in a manner similar to that used when taking piston bump marks and shown at "C" and "D," Figure 91, when crosshead is on the extreme end of its travel at each end respectively.

Main Rod Adjustment

If the crosshead travel marks lie centrally between the bump marks, the length of the main rod is considered O.K.

Should the main rods need adjustment take them down, adjust for length and leave them down until you have taken all the readings necessary before taking cut offs. Put up main rods later when ready to try cut offs.

Serious damage to cylinders and their heads has often been caused by making mistakes when lengthening or shortening a main rod with a view to equalizing the piston clearances at front and back end of a cylinder. A liner taken from the back end of the big end brasses and fitted in the front of same, lengthens the main rod. Vice versa, a liner taken from the front end of big end brasses and fitted in the back end of same next to the big end strap, shortens the main rod.

Lead and Valve Travel Lines

Lead lines are always taken in the case of Stevenson Gear with reverse lever in the full gear notch. Lead is always set to and figured from full gear readings, hence, when about to catch a dead centre, see that reverse lever is in the corner notch.

Run the wheels around in the direction indicated by reverse lever. Be sure that valve stems are moving, thus indicating all possible slack motion is taken up. Slightly jamming the

valve stem gland with some packing and by tightening up one side only of same is often done to ensure this. With wheel tram point placed in the fixed centre pop "P," wait for the nearest dead centre to come around and when it arrives exactly under the other point of wheel tram, stop the rollers.

If perchance the dead centre pop on the rim of the wheel slips by a little, DO NOT back the wheel in the opposite direction slightly to pick up the centre. Run back a matter of 8" or 10" until the valve stems are moving, then come ahead again and catch the dead centre properly without a slip.

When a dead centre is caught properly, take the valve spindle tram which was used to take port marks and bump marks of the valve and placing one point in the centre pop in cylinder plug before mentioned, scribe a line on valve stem. This line is called a "Lead Line," see "A," Figure 92.

Turn rollers to continue the movement of driving wheels in the same direction indicated by reverse lever and with the point of tram applied as when taking a lead line watch the valve stem move to a full gear valve travel. When the valve stem has reached its full extent of travel and same is on the point of return, scribe another line on valve stem, see "B," Figure 93. This line is called a "Full Gear Valve Travel Line."

The full gear lead lines and valve travel lines can be taken in this manner for both sides of engine and for both forward and back up gears. Hook up or Notch up valve travel lines can be taken by simply placing the reverse lever in the notch required and then continue as in the case of full gear valve travel lines.

The forward gear lead and valve travel lines are generally scribed as shown in Figure 94, mostly above and slightly below the straight scribed line, whereas the back up lead and valve travel lines are generally scribed mostly below and slightly above.

Measuring Slip of the Link and Link Block Clearance

After having scribed a lead line, the valve setter still holds the valve spindle tram waiting to take the full gear travel line. The valve setter's helper, generally an apprentice, having caught the dead centre for the lead line taken, now planks the wheel tram in a safe place and jumps down below to the links. He scribes lines or if there is no chance to do this,

owing to the case hardening of the link, he measures carefully the full movement of the link over the link block on the side of engine concerned. This is the slip of the link. He also measures the shortest distance which occurs between the top of the link block and the inside top of link, during this operation. This is Link Block Clearance.

These items are measured when valves are at both extreme ends of full gear travels in order to obtain the least link block clearance.

When the first full gear travel line is taken the valve setter passes to the right main driver and catches the next dead centre He now takes the valve spindle tram and scribes a lead line for the second dead centre taken which will occur on the other side valve stem as compared with first lead line taken. Continue in this manner until all forward lead and valve travel lines are taken.

It pays one to keep an eye on eccentric straps, etc., to see that valve rigging does not foul anywhere, such as on ash pan rigging, etc., during a complete revolution in full gear at this time. If same occurs, NOW is the time to arrange parts to clear.

The reverse lever can be placed in the back up full gear notch, and lead lines, travel lines, slip of the link and link block clearance obtained as well as making sure that nothing fouls the valve rigging during a complete revolution, in a similar manner to that just detailed for forward gear.

A Full Gear Reading

Figure 94 shows a forward and back up full gear reading. Let us assume that the steam lap of the valve is 1", the lead required 1/16" and the full gear valve travel specified at 6", also motion is indirect, with rocker arms of equal length. Set your dividers to exactly 1-1/16", i.e., equal to the steam lap plus the specified lead. Place the point of dividers in the centre pop indicating the central point between the two port marks and with the other point scribe two small arcs as at "D" and "E," Figure 94, which indicate the lead required.

Squaring Eccentric Rods from Full Gear Reading

To determine how much change to make in the length of the eccentirc rods from a full gear reading and whether to

lengthen or shorten same proceed as follows:—

With a pair of sharp pointed dividers, find the centre of the forward travel lines which proves to be in the reading taken and shown in Figure 94, 3/16″ behind the central point between the two port marks. The centre of the back up travel lines proves to be ¼″ ahead of this centre point.

The rule is "Always bring the centre point between the two port marks to the centre of the travel lines."

In the case taken, the port marks would have to be drawn backwards towards the centre of forward gear valve travel 3/16″ and having an indirect motion, the eccentric rod has to be lengthened this amount owing to engine being in full gear when reading was taken and the rocker arms being the same length. We also see that if same procedure is followed respecting the back up reading, that the back up eccentric rod will have to be shortened ¼″.

If the rocker arms had been of different lengths, i.e., the upper outer arm 18″ and the lower inner arm 12″ long, then the forward eccentric rod length change would be determined by multiplying the 3/16″ referred to by the length of the inner lower rocker arm in inches, i.e., 12″, then divide the result by the length of the outer or upper rocker arm in inches, i.e., 18″ and the answer would be to lengthen the forward eccentric rod ⅛″. The change to back up rod in this case can be figured out in the same way.

Whether to lengthen or shorten an eccentric rod depends whether motion is "Direct" or "Indirect."

A slotted hole in each eccentric strap when one bolt only is used for setting valves allows of temporary adjustment at this time.

If both eccentric rods need to be adjusted exactly the same amount in the same direction make both adjustments and DO NOT change the length of a valve rod instead.

Link Lifter Adjustment

Equalizing the length of forward and back up valve travels can be effected by adjustment of the link lifters, providing there is sufficient link block clearance in link in the full gears. If when a link lifter length is changed the link block fouls the link in full gear, a corner notch or notches in reverse lever rack have to be plugged according to the corner in which the reverse lever is found when the fouling occurs.

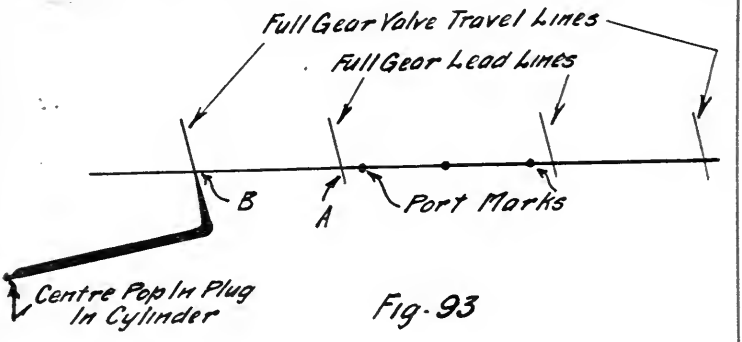


Fig. 93

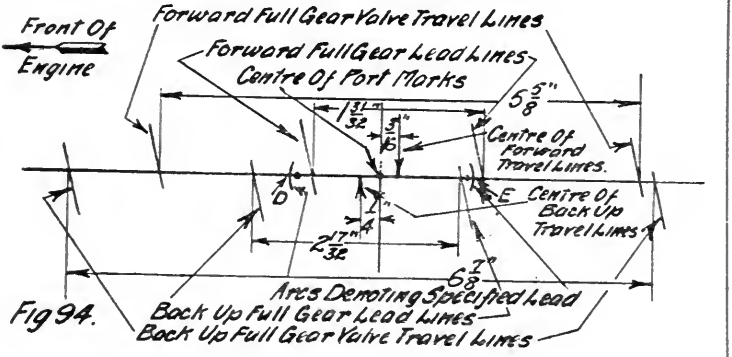


Fig 94.

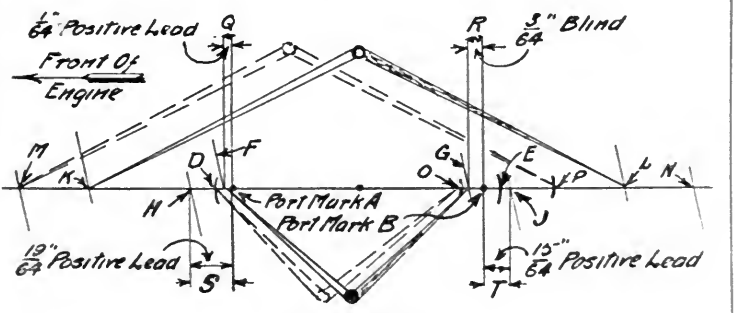


Fig - 95

Plugging a Notch

Sometimes a corner notch is plugged to hold a given full gear valve travel to its limits and sometimes to prevent a valve from striking its bumping point or danger mark as well as to be sure of link block clearance.

The Effects of Hooking Up

When a reverse lever is hooked up, towards the mid gear notch it has the effect of increasing the lead at both ends of each cylinder and shortening valve travel on both sides of locomotive dependent on the number of notches hooked up.

Effects of Shortening a Reach Rod

When a reach rod is shortened, other conditions remaining the same, and new valve stem readings are compared with those taken before the change is made, one finds the lead increased and valve travel decreased in forward gear also lead decreased and valve travel increased in back up gear on both sides of locomotive. Lengthening a reach rod causes an opposite effect.

Effects of Boiler Expansion

When a valve gear is affected by boiler expansion the effect on the lead and valve travels is the same as in the case of reach rod shortening when you compare the readings taken when boiler is cold and those taken when boiler expansion has taken place.

Effects of Plugging a Corner Notch

When a corner notch is plugged and a reading is taken with reverse lever in the new corner notch one finds as compared with reading taken with lever in the old corner notch that the lead is increased and the valve travel decreased in the gear only where the plugging is done.

Effects of Shortening a Link Lifter

Shorten a link lifter and you get the same effect as shortening a reach rod except that only one side of the locomotive is affected, i.e., the side on which the link lifter change is made. Lengthening a link lifter causes the opposite effect, to shortening same.

Effects of Movement of Eccentric Sheave Around Axle

Move an eccentric sheave around the axle, i.e., change its relation to the main pin and the lead is increased or decreased at both ends of cylinder according to the direction in which the change is made. Full Gear Valve Travel remains the same.

Effects of a Change in Eccentric Rod Length

Change the length of an eccentric rod and lead is increased at one end and decreased at other end of cylinder dependent on which way the change is made. This is effective on the side of the locomotive and in the gear where the eccentric rod controls the valve. The full length of the valve travel remains the same but there is a difference in the distance the valve travels on either side of the centre of valve seat as compared with that which occurred before the change. A change in the length of an eccentric rod in one gear does not affect the other full gear lead.

It does affect the lead in the other gear however, when reverse lever is placed in any other notch than the full gear, the extent of the effect being dependent upon the amount of eccentric rod change. The effect on the lead in the other gear is most pronounced, when the reverse lever is nearest to the mid gear notch.

The effects of a change in the amount of backset to a link saddle pin and the back set or front set of a rocker arm will be dealt with later in valve setting.

A Peculiarity of the Stevenson Link Motion

There are certain troubles which a designer of valve gears butts up against when he gets on to his job. His results depend on his skill and concentration the same as with you and your game, hence one of the peculiarities of a gear is likely to show up during valve setting, which to show more clearly what is meant a full gear reading similar to Figure 94 is shown in Figure 95, except that eccentric rods have been adjusted for length and same being exaggerated slightly in order to demonstrate how to measure lead figuratively for valve setting and how to measure lead for shop report.

Note how valve travel lines are equidistant from centre of port marks for each gear, also that lead lines are unequal distances from centre of port marks in each gear.

To measure lead at each end for the purpose of shop report at any time see the following:—

How to Measure Lead for Shop Report

Take the forward gear reading as an example by which to measure lead at front end. This distance shown at "Q," Figure 95, between the front lead line and front port mark indicative of that which occurs at the back steam port in this our case of inside admission valves proves to be 1/64" positive lead, whereas at the other end the lead is 3/64" negative, i.e., 3/64" blind, shown at "R," Figure 95.

Take the back up reading and the lead "S," Figure 95, measured in the same way from the front port mark to the front lead line shows 19/64" positive lead whereas the lead "T," Figure 95, at the front steam port and shown at back end of valve steam reading shows 15/64" positive lead. It follows that a sacrifice has to be made somewhere, and as in the case shown it is the general practice to square the eccentric rods to valve travel lines at the expense of the lead. One can get as nearly right as possible by measuring lead when figuring for adjustment in the following manner.

How to Measure Lead for Valve Setting Purposes

Set a pair of dividers to the distance between the two forward gear lead lines "F" and "G," Figure 95. Without moving dividers to change the measurement, carefully apply one point to the small arc "D" where it cuts the straight line and just mark the latter with the other point of dividers as shown at "O." Take the distance between point "O" and small arc "E," halve it and the result is the lead change required.

In all Cases of Stevenson Motion

When the distance between the lead lines, see "F.G.," Figure 95, is less than the distance between the two small arcs "D" and "E," Figure 95, "Lead On" is required. When the distance between the lead lines see "H.J.," Figure 95, is greater than the distance between the small arcs "D" and "E" then "Lead Off" is required.

The forward gear reading at the valve stem shows in this case that 5/64" "Lead On" is required. If measured in a similar manner the back up reading at the valve stem shows that 13/64" "Lead Off" is required.

How to Measure Valve Travels for Valve Setting Purposes

In order to measure for example full gear valve travels for lifter adjustment, set the dividers to the forward gear travel lines "K.L." on the straight line, see Figure 95. Without changing this measurement apply one point of dividers to point of intersection "M" and scribe with the other point of dividers a small mark as at "P," Figure 95. Measure the distance between point "P" and point of Intersection "N" on the other back up valve travel line. Halve this distance and the result is the amount the forward travel in this case has to be lengthened and the back up to be shortened by lifter adjustment.

How to Measure the Effects on Lead and Valve Travels by a Reach Rod or Lifter Length Change

One can almost hear the question: How much do you lengthen or shorten a lifter to square up the valve travels and how much does it affect the lead?

The answer is, owing to the peculiarities of the various lay-outs of Stevenson Valve Gears, one has to take the effects of a reach rod or lifter change on lead and valve travels for EACH class of engine ONCE and make a note of same for later reference during valve setting, on all engines of each class respectively.

Proceed as follows:—

Having taken full gear lead and travel lines in forward gear, i.e., with reverse lever in the full gear forward notch, take a tram (wheel tram will do), place one point in a centre pop, see "P," Figure 96, made on something rigid, for instance the boiler. With the other tram point scribe a line on reach rod as shown at "A," Figure 96.

Scribe a line "C.D.," Figure 96, with a pair of oddleg Calipers parallel to the centre line of reach rod and extending a couple of inches on either side of arc "A."

Hook up reverse lever one notch from the corner.

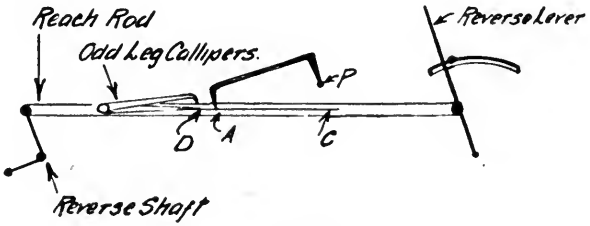


Fig. 96

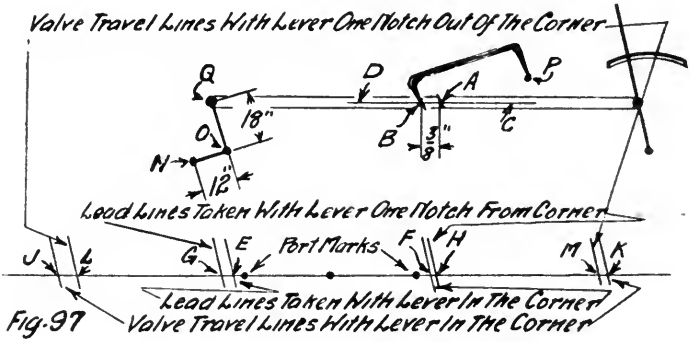


Fig. 97

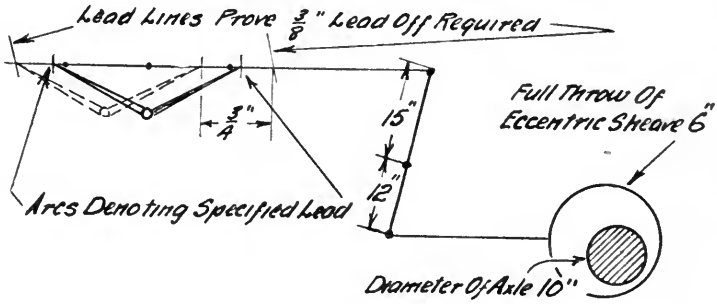


Fig 98

Place same wheel tram point in centre pop "P," Figure 96, and again scribe a short arc see "B," Figure 97, to cut line "C.D."

Now turn engine over to take another reading of the lead lines and valve travels in forward gear with the reverse lever one notch out of the corner.

The reason for all this work (which may be considered by certain valve setters as waste of time) is absolutely warranted for the simple reason that the peculiarities of many layouts of gears show readings similar to and often more pronounced than that shown in Figure 97. See the variation in lead and valve travel difference at each end.

In the case taken, the reach rod difference shows 3/8" and when the lead is measured up similar to the manner explained before, i.e., collectively, "E.F." taken from "G.H." and then halved or divided by two (2) the result is that lead is increased 1/32" at each end for a given 3/8" reach rod shortening, incidentally if a reach rod in full gear was lengthened 3/8" the lead at each end in forward gear would be decreased 1/32" and the lead at each end in back gear would be increased 1/32".

In the same manner if dividers are applied to valve travels and the second travel "L.M." is taken from "J.K.," the first travel scribed, the difference in this case 1/4" shorter is exactly what effect 3/8" shortening of a reach rod has on full gear forward travel. The back up full gear valve travel would also be lengthened 1/4" by the change.

Lengthen a reach rod 3/8" in this case and the full gear forward travel would be lengthened 1/4", also the back up full gear valve travel would be shortened 1/4".

The lower reverse shaft lifting arm, see "N.O.," Figure 97, is about two-thirds of the length of the reverse shaft upper arm see "O.Q.," Figure 97. It is easily seen when a given change in reach rod is found to cause a certain effect on full gear lead and valve travels on both sides of locomotive that two-thirds of that given change to length of reach rod, if made in a link lifter length, and the reach rod is not changed that the same effect would be caused to full gear lead and valve travels on one side of the locomotive only where the lifter change is made.

In other words, the proportionate change in a link lifter length having an equivalent effect as a given change in a reach

rod length, is in the same proportion as the length of the reversing shaft lifting arm when compared to the length of the upper reverse shaft arm.

It thus follows from the aforementioned that in the case of a switch engine where valves are always set from full gear readings, and a reach rod has to be changed, but not until after valve setting is done, that the effect of the change on lead and valve travels can be allowed for when valve setting.

After the reach rod allowance has been made and yet one finds the lifter lengths need adjustment to square the valve travels one can also note down the effect on lead which will be caused by lifter change, see later when following the train of moves when setting a switch engine.

After having figured out changes to lifters, if any, and the effects on lead, etc., it is found that certain changes to the lead in the forward and back gear is necessary to obtain the lead required on both sides of engine by movement of the eccentric sheaves, around the axle, proceed to figure out VERY CLOSELY the amount of ACTUAL movement of eccentric sheave with relation to the axle as follows:—

How far to move Eccentric around Axle to obtain a Required Change in Lead

Let us take one forward full gear reading showing lead lines for example, see Figure 98, allowing that the lead lines show exactly the change required. Assume for clear demonstration that $\frac{3}{8}''$ lead off is required, the length of upper outer rocker arm is 15″, the inner lower rocker arm length is 12″, the eccentric sheave full throw is 6″, and diameter of axle is 10″.

Multiply $\frac{3}{8}''$ by the length of the inner lower rocker arm in inches $\frac{3}{8}''$ x 12″ equals 9/2″.

Divide the product 9/2″ by the length of the outer upper rocker arm length in inches, i.e., 9/2″÷15″ and the result is 3/10.″

Multiply the last result 3/10″ by the diameter of the axle in inches, i.e., 3/10″ x 10″ and the result is 3″.

Divide the last result 3″ by the full throw of eccentric sheave in inches, i.e., 3″÷6″ and the final result is $\frac{1}{2}''$, the amount APPROXIMATELY that the eccentric sheave has to be moved around the axle, and measured around the surface of same where eccentric sheave touches it.

If the aforementioned had been a case where lead on was required the same approximate figuring should be made up to this point as in the case of lead off being required. Figure 99 will show why the figuring is only approximate. Let us compare both cases of 3/8" Lead On and 3/8" Lead Off. Take it for example that "O.A.," Figure 99, represents the centre line of the web of eccentric sheave, when the required lead is O.K. Let "O.B." represent the position of the centre line of eccentric sheave when 3/8" lead on is required. Let "O.C." represent the position of the centre line of eccentric sheave when 3/8" lead off is required. By referring to Figure 99 or laying out to scale yourself it will be seen that the sheave has to be actually moved around the axle 17/32" to obtain 3/8" lead on and 9/16" to obtain 3/8" lead off. Thus it follows:—

Make your calculation and if a beginner (an old hand knows by experience) make a small layout to scale on a flat brass plate as shown in Figure 100 to obtain the exact amount of movement of an eccentric sheave around the axle.

Don't guess, boys, go right to it and be sure.

Cut Offs

Whilst an engine can be square as far as eccentric rods, valve rods, reach rod and lifters are concerned, also the lead O.K., yet it is possible for the Cut Offs at each end of cylinder for each gear respectively on both sides of locomotive to be unequal.

If the difference in Cut Offs at each end of cylinder is kept within 3/4", the forward and back up gear being considered separately, the engine is generally accepted as being well set.

It is good practice after having adjusted the length of eccentric rods, to try the cut offs. Put up main rods, same having been adjusted for length. The effects and allowances on Cut Offs will be treated also in the next chapter but at this time let us follow the taking and squaring of cut offs in forward full gear on one side of locomotive.

Place reverse lever in forward corner notch.

Move engine around forward until valve stem moves.

All possible slack motion having been taken up in this manner, turn engine until the port mark which represents a front cut off, arrives exactly under the point of the valve stem tram when held in the same position as when port marks were

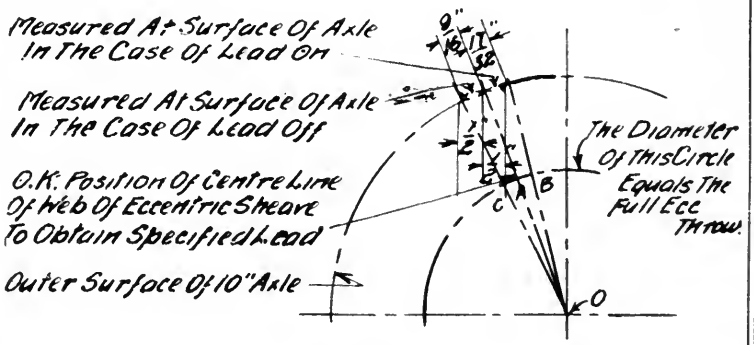


Fig-99

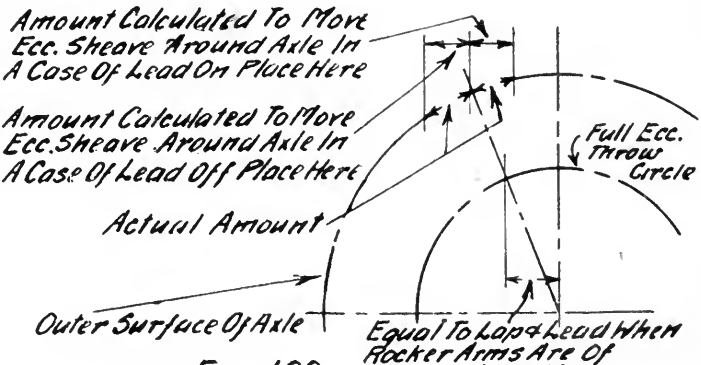


Fig-100

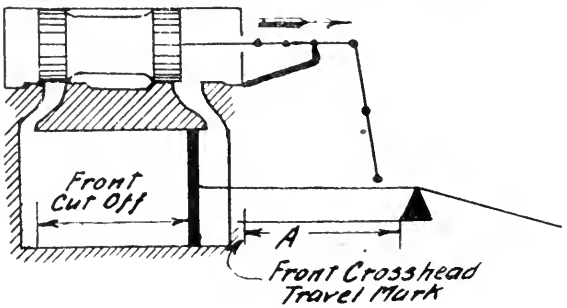


Fig-101

taken, see Figure 101. Stop engine and measure the distance that the crosshead has moved from its front travel mark, see "A," Figure 101.

Make a note of the length of this Cut Off.

Continue to turn engine in the same direction until the port marks representing the point of Cut Off for the back port arrives exactly under the valve stem tram point when held as before explained.

Stop engine and measure the distance the crosshead has moved from its back travel mark, see Figure 102.

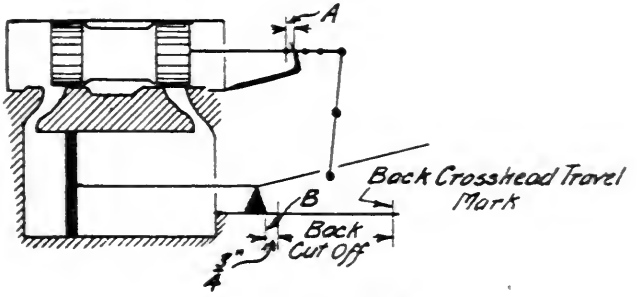


Fig - 102

Compare this back Cut Off with the Front Cut Off and if equal the Cut Offs are O.K.

If Cut Offs are not equal take the shortest one from the longest and halve the difference.

Suppose the back Cut Off was 22" and the front Cut Off 23½" take 22" from 23½" and 1½" remains. Half of this remainder equals ¾". Turn engine around to pick up the shortest, in this case, the back, Cut Off. Tack on ¾" by moving engine around until crosshead runs by the 22" and stop when 22¾" is reached, see "B," Figure 102.

Apply one point of valve stem tram in the centre pop in the plug in cylinder as before and with other point of tram scribe a line on valve stem, see Figure 102. The distance "A" between this scribed line and the port mark which has just slipped by is the amount of alteration which has to be effected by a change made in the length of eccentric rod to obtain equal Cut Offs at front and back end of cylinder in that gear.

If a movement is made to equalize the Cut Offs after having squared eccentric rods from valve travels, by further adjustment of eccentric rods, there becomes a difference in the lead at one end of the cylinder as compared with the other.

Squaring the service Cut Offs, i.e., the Cut Offs where engine does most of its work, is considered good practice at the expense of the lead if ncessary.

The effect on full gear Cut Offs for a given reach rod or lifter change can be easily found if you need same at any time when squaring by the Cut Offs, by taking the two full gear Cut Offs in inches as shown in Figure 101 and 102 and adding them together.

Hook up the reverse lever one notch out of the corner, having scribed the reach rod, etc., as explained and shown in the case given in Figure 97. Take it for granted the amount of Reach rod change is $\frac{3}{8}''$ as before. Take the Cut Offs at both ends of cylinder again and add the two together. Take the sum of the two last Cut Offs from the sum of the first two full gear Cut Offs, halve the remainder and the result is the effect on a full gear Cut Off for a given Reach Rod alteration, $\frac{3}{8}''$ in this case.

An effect on Cut Offs owing to a lifter length change can be figured in proportion according to the length of the upper and lifting reverse shaft arms.

Chapter V.

Important Points to Remember with Stevenson Link Motion.

THE nearer a designer can get to an ideal lay out, the broader the field of service is extended in which the locomotive can work efficiently and economically.

It is not good shop practice or policy for a valve setter to figure beyond the following, unless especially ordered to do so.

For a Switch Engine.

Square the lead from full gear readings.

Square the lifters from full gear valve travels.

Square the eccentric rod lengths from full gear valve travels and then try the Cut Offs.

Make the valve rod lengths and reach rod lengths right, and as there is only one right when O.K., DON'T CHANGE THEM.

Square the eccentric rod lengths finally to the full gear Cut Offs, if after squaring their length to the full gear valve travels, the difference in the full gear Cut Offs, on each side of engine in each gear respectively, prove to be not more than $1\frac{1}{2}''$. If same shows a difference of 3″ or 4″ depend on it you will have to change the back set of link saddle pin. This is explained later in chapter.

For a Freight Engine.

Square the lead from full gear readings.

Adjust eccentric rod lengths in the first place from full gear valve travels.

Square the lifters from the hook up valve travels, i.e., travels taken when reverse lever is placed in a notch which will cause the valve to Cut Off live steam when piston has travelled approximately one-third of its stroke.

Square the eccentric rod lengths in the second place to the hook up valve travels.

Make the valve rod and reach rod lengths right in the first place, and DO NOT ALTER THEM.

Square the eccentric rod lengths finally to the hook up Cut Offs, if after squaring them to the hook up valve travels, the difference in Cut Offs on each side of engine in each gear

respectively prove to be not more than 2″. If same proves to be 3″ or more, figure on a change to the back set of link saddle pin, see later, in chapter.

For a Passenger Engine.

The same as in the case of a freight engine, with this one exception :

When hooking up for service cut offs place the reverse lever in a notch to give approximately 25% Cut Offs, i.e., to Cut Off after piston has travelled approximately one quarter of its stroke.

One hears the remarks "Why does an engineer during operations hook up the reverse lever beyond the notch where valves are set ?" The answer is, the engineer uses his own judgment when feeling out his engine for economical results compatible with speed and often approaches very close to the mid gear notch.

If when valves are set on any engine as per the ruling herein given and the engineer sees fit to notch up a little higher, there will be no appreciable difference in the equality of the Cut Offs as compared to Cut Offs by which engine was set.

Present day reverse lever racks are generally slotted regularly the full length, and a double reverse lever catch is arranged whereby a half way position between each rack tooth can be obtained.

The corner notches are generally determined by full gear valve travel specifications.

If in doubt where to place a reverse lever for a given Cut Off, approximately, proceed as follows:—

Reverse Lever Position for a Given Cut Off.

For example, take a passenger engine required to be squared at 25% Cut Offs and the piston stroke is 30″.

Place the reverse lever in a notch about 4″ from mid gear notch and in the forward gear.

25% or ¼ of a 30″ stroke is 7½″.

The sum of two 7½″ Cut Offs equal 15″.

Take the front and back Cut Offs in forward gear for one cylinder. Assume the front Cut Off as 8½″ and the Back Cut Off as 8″.

Add the two together and the result is 16½", which is greater than 15", the sum of the required back and front Cut Offs by 1½".

Halve this difference and ¾" is the result.

Take this result from the longest Cut Off, 8½", which happens to be at the front in this case, and 7¾" remains. Throw reverse lever into forward full gear. Turn engine forward until valve stem moves, continue until the crosshead reaches a 7¾" Cut Off at the front end, then stop the engine.

Place valve spindle tram as in the case of taking a point of Cut Off. Get your helper to hook up the reverse lever towards the mid gear notch carefully, until the port mark which indicates the point of Cut Off at front end of cylinder reaches a point exactly under the point of valve spindle tram when held properly.

When this occurs drop the catch of the reverse lever into the nearest notch of the rack, same being approximately the notch for setting valves to 25% Cut Offs.

The eccentric rods should be adjusted to full gear valve travels first, before the aforementioned 25% notch up Cut Off position is sought.

Hook Up Valve Travels.

In the case of Hook Up Valve Travels being required in order to square the lifters, same can be taken in a similar manner to the full gear valve travels, the only difference being that the reverse lever is placed in the hook up or running notch position instead of being in the corner.

Squaring the Eccentric Rod Lengths from the Hook Up Cut Offs.

When squaring by the notch up Cut Offs same can be done in a manner similar to that detailed for Full Gear Cut Offs as far as finding the amount of change scribed on valve stem to be effected by adjustment of eccentric rod lengths.

Squaring Eccentric Rods from Hook Up Valve Travels.

The sure way of finding how much to adjust in the lengths of eccentric rods with one calculation from a valve stem reading taken with reverse lever in the running notch proceed as follows:

After scribing a lead line with reverse lever in a corner notch and with the main pin still on a dead centre, hook up

the reverse lever to the running notch before moving the engine around.

Now get underneath the engine and measure the distance as shown at "A" Figure 103. Let us assume for example this distance is 12". Measure also the distance "B" Figure 103. Let us assume this distance as 3". Move reverse lever into the back up running notch of rack without moving engine around. Measure the distance "C." Let us assume this distance as 3". The distances "B" and "C" Figure 103, generally prove to be about equal. Take it for granted the rocker arms are of equal length and when the hook up valve travel lines are taken the reading demands a pushing ahead of the valve ¼" by adjustment of the forward eccentric rod, see Figure 104, also a pulling back as it were of the valve 3/32", by the adjustment of the back up eccentric rod.

Let us still adhere to an engine with Indirect Motion. By referring to Figure 104 a valve stem reading on the left side is shown above a skeleton sketch of a link and eccentric rods.

Note that "A" and "B" represent the positions of link block in link when the reverse lever is hooked up respectively in forward and back up gear when main pin is on a dead centre.

To obtain the required effect in forward gear just imagine you can move the link so as to turn about the point "B" without having any effective movement on the back up gear, yet to move the point "A" back ¼" to a new position "C."

The rocker arms being of the same length, the required alteration at the valve stem is effected. Take note the link has been moved to another position indicated by the dotted line, necessitating a shortening of the forward excentric rod ⅜", and a lengthening of the back up eccentric rod ⅛", which is easily seen from the proportionate distances shown. Note these down as first changes.

In a similar manner imagine you can hold the point "C" in the new position and move the point "B" ahead 3/32" to point "D." This means a further lengthening of the back up eccentric rod 9/64", and a further shortening of the forward eccentric rod 3/64". Add the two changes for each rod respectively and separately and the final actual change to be made to the forward eccentric rod is to shorten same 27/64", and to lengthen the back up eccentric rod 17/64".

Figuring out changes to eccentric rods from a hook up reading in this manner can be depended upon, and needs only

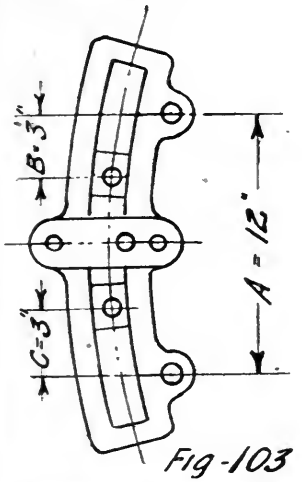


Fig-103

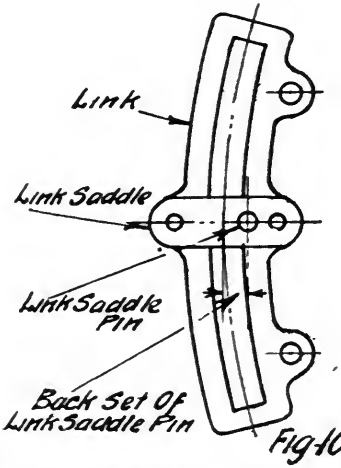
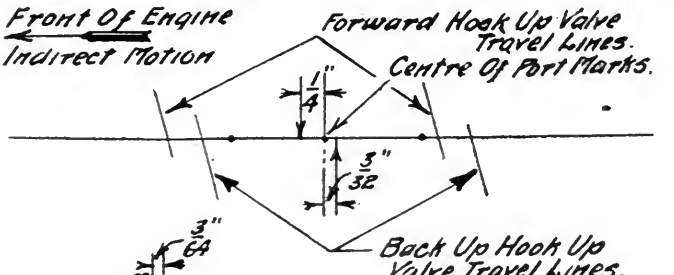
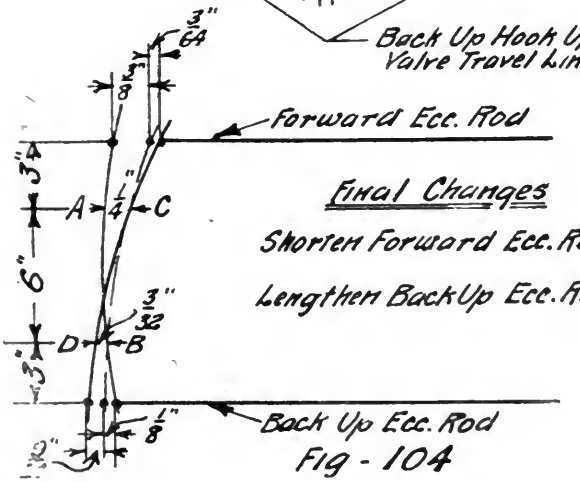


Fig-105





Final Changes

Shorten Forward Ecc. Rod $\frac{27}{64}$"

Lengthen Back Up Ecc. Rod $\frac{17}{64}$"

Fig - 104

a trial to confirm same. It is especially useful when an engine is needed on the outgoing track in a hurry, etc.

Effects on Lead and Hook Up Valve Travels for a Given Reach Rod or Lifter Length Change on Freight or Passenger Engine.

In the case of a freight or passenger engine the effect on full gear lead for a given reach rod or lifter length change can be found in the same manner as explained for a switch engine. The effect on hook up valve travels for a given reach rod or lifter length change can be found in the same manner as explained in the case of full gear valve travels on a switch engine, except that the reverse lever is placed in the running notch for the first valve travels scribed and hooked up a notch nearer mid gear when the second set of valve travels are taken.

Keeping Check on Actual Changes.

When about to make final changes in the lengths of rods, etc., check same before and after the change is made. Don't trust anybody.

Ask for what you want if somebody else is making the change. It is up to you to see that you get it right.

Points Worth While in Cut Offs.

Bear in mind, an engine is considered O.K. when squared to the live steam Cut Offs. No Need to Worry About Squaring the Exhaust Cut Offs.

Hooking up a reverse lever towards the mid gear notch during operation shortens the Cut Offs at both ends of cylinders on both sides of locomotive in the gear indicated by the reverse lever position.

Shortening a reach rod length shortens the cut offs at both ends of cylinders on both sides of locomotive in forward gear, and lengthens the cut offs at both ends of cylinders on both sides of locomotive in back up gear, when compared with that which occurred before the change.

Lengthening the reach rod has a opposite effect to shortening.

Shortening a link lifter has the same effect on cut offs as shortening a reach rod, except that one side of engine only is affected, depending on which side the link lifter change is made.

Lengthening a link lifter has the opposite effect on cut offs as compared with shortening same.

Boiler Expansion has the same effect on Cut Offs as shortening a reach rod.

Movement of an eccentric sheave around the axle to give "Lead On" shortens the cut offs at each end of the cylinder on that side and in the gear where the affected eccentric sheave actuates the motion of the valve. When moved to take "Lead Off" an opposite result is affected when compared with giving "Lead On."

Adjustment of an eccentric rod length will cause the cut off at one end of cylinder to be lengthened, whilst the cut off at other end is shortened, dependent on which way the adjustment is made. This applies to the side of the engine and to the gear in which the eccentric rod is used to control the valve.

Movement of an eccentric sheave or an adjustment of an eccentric rod in one gear affects the hook up or running cut offs (not the full gear cut offs), in the other gear on the same side of engine where change is made.

Incorrect Back Set of a Link Saddle Pin.

When eccentric rods have been squared to hook up readings it is practically impossible in present day valve gears to throw a difference in hook up cut offs in the one gear beyond 1½" to 2", by having an incorrect set to lower or inner rocker arm, owing to the abnormal difference in cut offs set up by the latter, being counterbalanced to a great extent by adjustment of the eccentric rods.

Thus it follows that after squaring eccentric rods to the hook up travels and an extraordinary difference, say 3" or more in the cut off at one end of cylinder is found as compared with the other end, then the back set of the link saddle pin has to be adjusted.

To do this, take the link down, noting first whether the link saddle is loose enough to allow of working or movement with respect to the link when in operation. If so, same may be the cause of the trouble.

In any case, scribe the link saddle with respect to the link before separating them.

The back set may have to be increased or decreased. The exact amount will have to be determined by trial. Figure 105 shows the back set of link saddle pin.

Try out by increasing the back set 1/8" with temporary bolts well tightened through link and link saddle.

Replace same on engine and make the necessary connections.

Square up the eccentric rods to another hook up reading taken on the affected side or sides. Try the Cut Offs, and if an improvement is shown the movement of link saddle pin has favored same. If not make the change in an opposite direction.

Do not expect to square the cut offs exactly.

If the result shows a difference in Cut Offs to be within ¾", and the set of the inner or lower rocker arm is in the right direction, smile and let her go.

After the new position of the link saddle, with respect to the link is found, the bolt holes will have to be reamed out to suit and new bolts or rivets applied.

Laying Off Eccentric Sheave Key Ways.

Eccentric sheave key ways are generally marked off and machined, also eccentric sheaves fitted and keyed to the axle of the main driving wheels before being shipped to the Erecting Shop.

To lay off the eccentric sheave keyways on the axle ready for machining, no matter whether the wheels are pressed on the axle or not, proceed as follows:—

Take a piece of flat plate, preferably brass, and place a sharp light centre pop in same as shown at "A" Figure 106. Set your sharp divider points to half the diameter of the axle where the eccentric sheaves have to be fitted.

Place one point of dividers in centre pop "A" and scribe a circle with the other point of dividers, see "B.E.C.D."

Now set your dividers to half the full throw of eccentric sheaves. Place one point of dividers in centre pop "A" and scribe another circle, see "F.G.H.J." Scribe two straight lines "B.C." and "D.E." at right angles to each other, both of which pass through the centre of centre pop "A."

It has been previously explained that the centre line of motion of eccentric rods occur as per the design of the motion. This

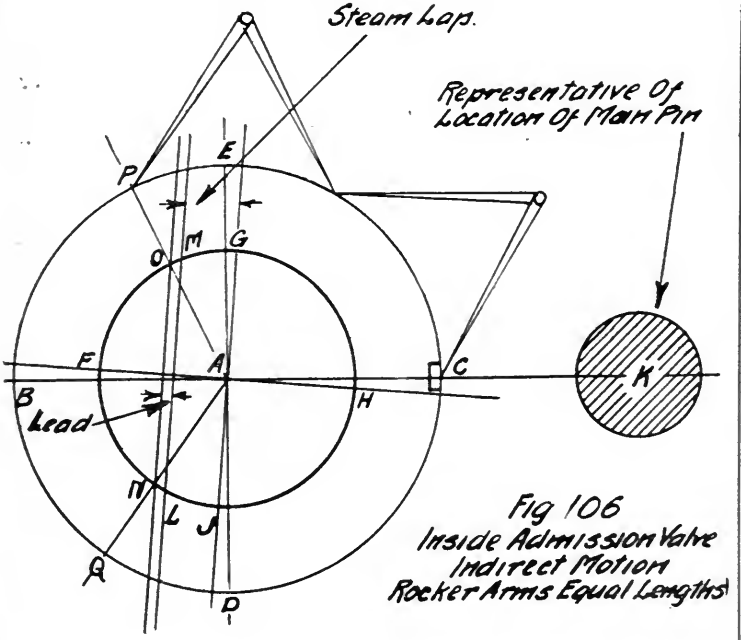


Fig 106
Inside Admission Valve
Indirect Motion
Rocker Arms Equal Lengths

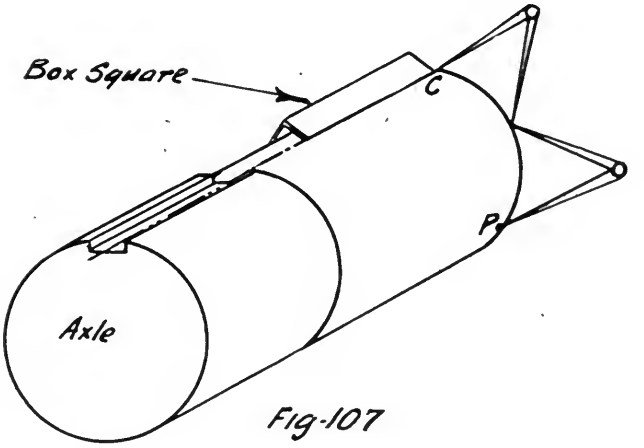


Fig-107

centre line of motion lies at an angle generally to the line "A.K," which passes through the centre of axle and the centre of main pin.

Scribe a straight line "F.H" representing the centre line of motion to pass through the centre of centre pop "A," and at an angle to the straight line "A.K," according to the blue print instructions.

No matter if the centre line of motion of eccentric rod coincides with the straight line "A.K," or if it is elevated or depressed with respect to same, the eccentric sheave keyways are laid off on the plate from the centre line of motion.

Let the straight line "F.H" Figure 106 represent the centre line of motion of eccentric rods for this our example. The straight line "A.K" passes through the centre of the keyway which is used to key the main driving wheel centre to the axle, as shown at "C."

Lay off a straight line "J.G" at right angles, to straight line "F.H" and passing through the centre of centre pop "A."

By tracing or by reference to blue print one can find on which side of the line "J.G," the centre of eccentric sheave keyways will occur.

Let us continue with a case of inside admission valves and indirect motion. This means, the keyways will occur on the other side of the line "J.G," when compared with the side on which the crank pin is situated.

Scribe a line "L.M" accordingly, parallel to "J.G" and on the side furthest from the main pin. The distance between the two lines measured along the line "F.H" must equal the lap of the valve, when rocker arms are of equal length.

It may possibly occur that "positive lead" is specified for both gears, or the valve to be "Line and Line" in both gears, or it may be that "Positive Lead" is required in one gear and "Negative Lead" in the other. In any case mark off from line "L.M." Take for example that positive lead in both gears is required.

Lay off a straight line "N.O" parallel to "L.M", the distance between the two lines measured along the straight line "F.H" being equal to the amount of "Positive Lead" required.

Note in all cases where "Positive Lead" is required that the lead is laid off from the line "L.M" in a direction away from the centre pop "A," whereas "Negative Lead" is laid off from

"L.M" along "F.H" in a direction towards the centre pop "A."

The straight line "L.M" represents a case where valve is "Line and Line."

To continue with our example scribe two straight lines from centre pop "A" to pass through the two points "N" and "O" respectively.

"N" and "O" are points where the straight line "N.O" cuts the circle representing the full throw of eccentric sheaves.

The straight lines "A.O" and "A.N" are scribed long enough to cut the circle which represents the axle diameter, at the points "P" and "Q."

"P" represents the centre of keyway for forward eccentric sheave, and "Q" the centre of keyway for the back up.

The centre of an eccentric sheave keyway which is cut in the eccentric sheave conforms to the centre line of the web or crank of the eccentric sheave.

In order to lay off the points "P" and "Q" on the axle, with respect to the position of the main pin, locate the centre of the wheel centre keyway as at "C."

If the main driving wheel axle is not already pressed into the wheel centres, lay off the wheel centre keyways on axle, which are usually spaced one 90 degrees ahead of the other.

Transfer the centre line of wheel centre keyway along the axle to the place where eccentric sheaves are to be fitted to axle with the aid of a box square, see Figure 107.

The location of eccentric sheave positions sidewise can be taken from blue print.

Now set a pair of dividers to half or even one-third the distance "P.C" Figure 106 taken on the circle, representing the axle circumference. If divider points are kept sharp and the centre pops on axle are made very fine, the positions of "P" and "Q" Figure 106, can be transferred very accurately on the axle, as shown in Figure 107.

The completion of the lay out of the eccentric keyways is a simple matter once the centre line of same is obtained in the manner just explained.

When care is exercised the keyways on the left and right sides of axle can be laid off without "mixing things."

In the case where wheels are already pressed on the axle, locate the centre line of wheel centre keyway. This usually cuts a straight line which passes through the centre of axle and the centre of main pin. This must be found on the axle between the wheels. It is generally found in a practical way with the use of a jig.

The jig is carefully made with a turned pin as shown at "E" Figure 108. The base of the jig is machined to fit the axle diameter of the class of engine the jig is intended for. When the jig is made, it is carefully laid off, inasmuch that the mark "D" lies radially correct on a straight line, if same could be scribed from the centre of the axle to the centre of the turned pin of the jig.

When applying the jig to an axle, as shown, see that the parts are cleaned and the point of the pin "E" falls into the centre of the inside end of main pin. If point of pin falls a little below the centre of main pin, be sure that it is held O.K. on a radial line scribed from the centre of inside end of main pin towards the centre of axle.

Scribe a mark on axle at the end of the line "D," which is already on the jig.

With the use of a box square scribe a line lengthwise on the axle from this mark. Consider this line as the continuation of the centre line of wheel centre keyway.

You can now proceed as before explained to lay out the centre lines of the eccentric keyways, etc.

The foregoing is a good practice, and if owing to a possible re-arrangement of the parts of an engine during construction, and an effect on lead is caused, then same can be adjusted by stepping the eccentric key when valve setting.

To Find Approximate Length of Eccentric Rods.

To obtain the approximate length of eccentric rods:—

Level main frames.

Disconnect the link in order to be able to move rocker arms, etc., for convenience.

Drop a plumb line through the centre of rocker shafts as at "R" Figure 46.

Drop a line over main driving axle as at "S" Figure 46.

Measure the distance between these two lines as seen at "T" Figure 46.

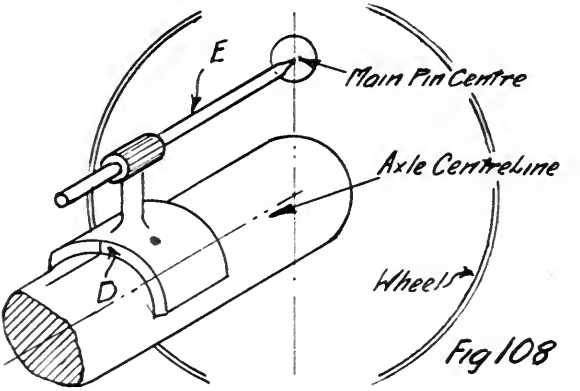


Fig 108

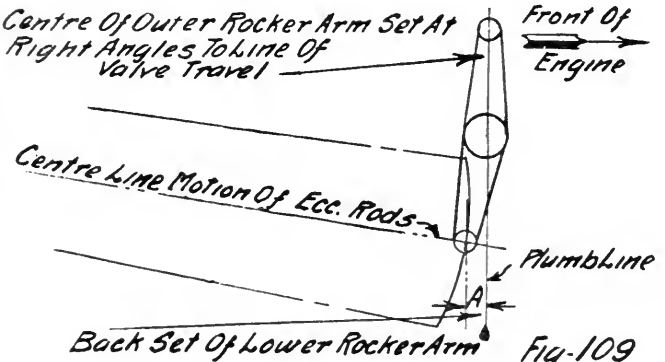

Centre Of Outer Rocker Arm Set At Right Angles To Line Of Valve Travel
Front Of Engine
Centre Line Motion Of Ecc. Rods
Plumb Line
A
Back Set Of Lower Rocker Arm

Fig-109

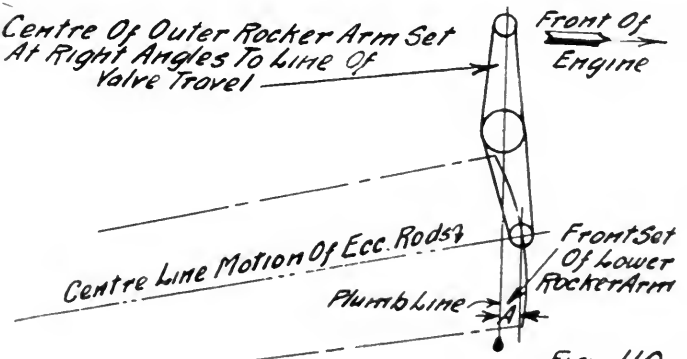

Centre Of Outer Rocker Arm Set At Right Angles To Line Of Valve Travel
Front Of Engine
Centre Line Motion Of Ecc. Rods
Front Set Of Lower Rocker Arm
Plumb Line
A

Fig - 110

To the distance "T" add half the diameter of the main driving axle and obtain the distance "U" Figure 46.

From this distance "U" take away the amount of backset of the inner rocker arm as shown at "A" Figure 109, if any is present or if a case occurs as shown in Figure 110, add the distance "A" Figure 110 to the distance "U" shown in Figure 46.

Now take away from the last result the distance from the centre of link pin to the link radius, as shown at "G" Figure 49.

Again take away the distance from the centre of eccentric strap to the butt for the eccentric rod as shown at "A" Figure 111.

Finally deduct ¼" from last result to allow for eccentric rod adjustment, and you have the approximate length of eccentric rod from centre of clevice pin to the end of eccentric rod where it butts eccentric strap.

Another method when rollers are under main driving wheels, by which each eccentric rod approximate length respectively can be obtained quickly is as follows:—

Take for example forward gear right side. Place reverse lever in forward corner notch. Spot right main pin on front dead centre. Set main valve on right side of engine to specified full gear lead at the front port.

Raise the right forward eccentric strap which is properly applied to its sheave, in a line with top link pin centre, and get your helper to hold the link about square to the eccentric rod centre line of motion.

Measure from the centre of top link pin hole, to the butt of the eccentric strap and deduct from this distance ¼" for eccentric rod adjustment and you have the required approximate length for blacksmith.

Take each eccentric rod approximate length in a similar manner separately, taking a dead centre for each side of locomotive and having the reverse lever in the forway or backup corner notch when measuring the length of the respective rods. If a back dead centre is used, set the valve to the specified lead at the back port. If a front dead centre, use the front port.

To Find Approximate Length of a Link Lifter.

Plumb the upper reverse shaft arm. Set the outer rocker shaft arm at right angles to the line of the travel of the main valve on the side of engine where lifter length is required.

Place the link in a position so that a straight line drawn through the centres of the two link pins stands approximately at right angles to the centre line of motion of the eccentric rods, using a block of wood to keep the link block in the centre of the link.

The distance from the centre of link saddle pin, shown at "O" Figure 46 to the centre of reverse shaft lifting arm pin centre, shown at "M" Figure 46, can now be measured as the approximate length of the link lifter required.

Chapter VI.

Valve Setting on a Switch Engine Fitted with Stevenson Link Motion

Assume for example that the steam lap of the valves is 1″.
The specified full gear lead in both gears is 1/16″.
The specified full gear valve travel is 6″.
The full throw of eccentric sheaves is 6″.
The diameter of axle where eccentric sheaves are fitted is 9″.
The rockers are indirect.
The rocker arms are of equal length.

The upper reverse shaft arm is one and a half times as long as the reverse shaft lifting arms.

The reach rod is not affected by boiler expansion.

That full gear lead is affected 1/32″ at each end of cylinder when the reach rod is lengthened or shortened ½″.

That full gear valve travel is affected ¼″, i.e., ⅛″ at each end when the reach rod is lengthened or shortened ½″.

That motion is assembled except eccentric straps and rods, valves and valve rods.

The pitch of the reverse lever rack teeth and lever catches are such that will allow the reach rod to be moved ½″ at each notching as lever is being hooked up.

Obtain the information required for valve setter's shop report before main valves are put in steam chest, i.e.—

Length and width of steam ports.
Type of valve.
Inside or outside admission valves.
Thickness of valve lip if a "D" Valve.
Whether "Allen" ported if a "D" Valve.
Thickness of valve seat if a "D" valve is used.
The steam lap of the valves.
The exhaust clearance, if any, or the exhaust lap of valves.
Eccentric sheave full throw, or any other items required which can be taken at this time.
Blow out steam passages from boiler to steam chests.
Put main valves in.
Put steam chest covers on in the case of piston valves.

Take valve bump marks or danger marks.

Take port marks allowing for valve stem expansion and piston rod volume in the case of INSIDE ADMISSION VALVES ONLY.

Scribe two small arcs equidistant from the centre of the two port marks to indicate the specified full gear lead.

Apply loose tin coverings to protect valve stem readings during valve setting.

Put on steam chest covers at this time in the case of "D" Valves.

Blow through and clear steam ports from valve chests to cylinders

Put in pistons and connect to crossheads, seeing that piston rod glands, etc., are on piston rods properly.

Drive home the piston rod cotter in crosshead.

Put up front cylinder heads and tighten three or four nuts.

Take piston bump marks.

Jack main frames level.

Put up valve rods when valve stem glands, etc., are on O.K.

See that valve rod cotters are driven home properly.

Check up valve rod lengths, and if a change is necessary, MAKE IT NOW.

Check up reach rod length. If same is adjustable, plumb the reverse shaft upper arm when reverse lever is in mid-gear notch of rack at this time. If reach rod is not adjustable and it is not convenient to make the change at this time, make a note of the actual change to reach rod length required. The figurative change to reach rod length for valve setting purposes equals the actual change in this our case, where reach rod is not affected by boiler expansion. Assume that reach rod requires shortening $\frac{3}{4}$".

Put rollers under the main driving wheels properly.

See that main driving horn binders are tightened up.

Set up main driving wedges.

Put up main rods.

Adjust main rod wedges or drive cotters as case may be.

Go over the motion and see that rocker and reverse shaft brackets are bolted properly and all motion pin nuts are tight.

Check up full throw of eccentric sheaves and incidentally their approximate position with respect to the main pin. Now is the time to correct errors.

Put up eccentric straps and see that same can be pulled around one complete turn easily when bolted tight.

Take out all unnecessary sets and twists from eccentric rods.

Put up eccentric rods and bolt with one bolt on the strap end in the slot hole.

Tighten link pin nuts.

Adjust the reverse shaft balance spring and see that reverse lever can be moved freely in both directions from one corner to the other.

Place reverse lever in full gear forward notch and see that same is not moved until you are ready to take a back up reading.

Turn engine in forward gear and find a dead centre.

Back up the engine until this dead centre found passes the point of wheel tram when held properly 8″ or 9″.

Come ahead again and catch this dead centre with wheel tram.

Scribe the lead line on valve stem for this dead centre.

Scribe the piston crosshead travel mark for this dead centre.

Send apprentice underneath to measure the slip of the link and link block clearance whilst you scribe the full gear travel line as the helper moves engine around forward.

Keep an eye out to see if valve rigging fouls anywhere.

If eccentric straps foul the ash pan door clear same immediately.

Keep an eye on disinterested individuals who may possibly move the reverse lever without your knowledge, thus rendering a false reading. This frequently happens and causes unnecessary extra labor.

Find the next dead centre.

Back up the engine as in the case of the finding of the first dead centre, come forward again and catch this second dead centre.

Scribe the second lead line.

Scribe the piston crosshead travel line whilst on this dead centre.

Continue in this manner and in one complete revolution of the main driving wheels forward obtain the following:—

The four dead centres.

The four piston crosshead travel lines.

The forward full gear valve travel lines.

The forward full gear lead lines.

The link block clearances in forward gear.
The slip of the links in forward gear.
Whether the motion fouls or clears in forward full gear.
Take down the main rods.
Adjust the main rod lengths if necessary.
Leave the main rods off until required to try the cut offs.
Place reverse lever in the full gear back up notch.
Turn engine in a back up direction and with one revolution of the wheels obtain the following:—
The back up full gear travel lines.
The back up full gear lead lines.
The link block clearances in back up gear.
The slip of the links in back up gear.
Whether the motion fouls or clears in back up full gear.

If it is not known what effect a change in the length of a reach rod or link lifter has on full gear lead and on full gear valve travels, NOW is the time to find out same. Explained previously. Note same for future reference.

A valve stem reading is shown in Figure 112, and represents a full gear reading for one side of a locomotive. This will serve as an example although both sides of locomotive have to be considered.

Adjust forward and back up eccentric rods from the full gear reading. This is possible owing to the slot holes in the eccentric straps.

Reach rod has to be shortened after valve setting $\frac{3}{4}''$.

Owing to reach rod shortening, figure the forward full gear valve travel which measure $6\frac{3}{4}''$ to be shortened up to $6\frac{3}{8}''$ (see reach rod effect on full gear lead and full gear valve travels at beginning of this chapter).

The forward full gear lead if measured for valve setting purposes in the simple manner before explained, is seen to be 5/32" but will be increased to 13/64" when reach rod length change is figured on.

Similarly the back up full gear valve travel taken from the valve stem reading as $5\frac{3}{4}''$ will be increased to $6\frac{1}{8}''$.

The back up full gear lead seen on valve stem reading as 1/32" blind will figure out as 5/64" blind.

To equalize the valve travels we now have, owing to the proportionate length of the reverse shaft arms, it is necessary to shorten up the link lifter, 11/64" bringing the forward and back up travels each to $6\frac{1}{4}''$.

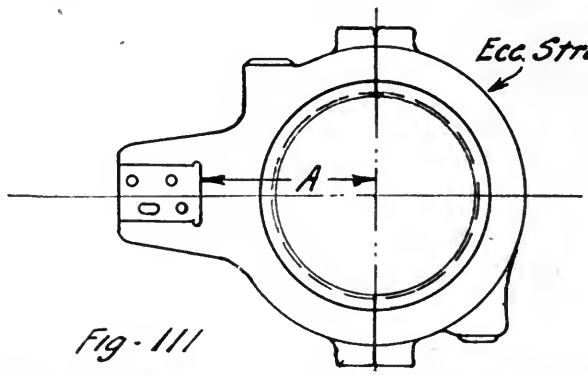


Fig - 111

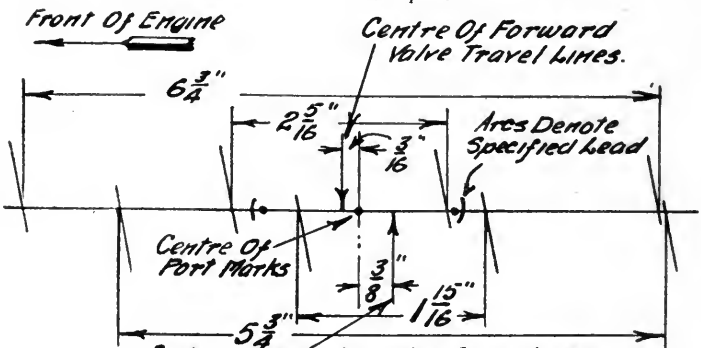


Fig - 112

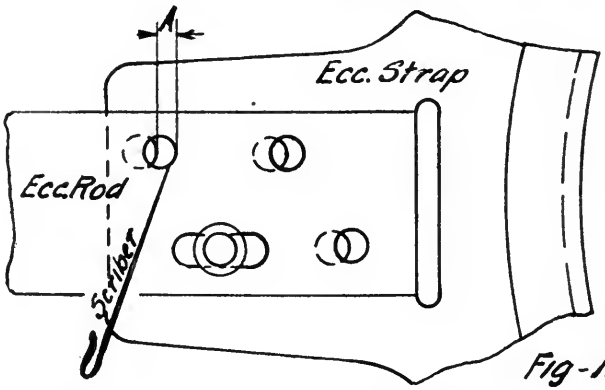


Fig - 113

Note down 11/64″ as the actual change to make in link lifter length, but not at this time.

Figuring on this lifter change, the forward full gear lead figuratively speaking now at 13/64″ will be increased to 7/32″ also the back up full gear lead now at 5/64″ blind will become 3/32″ blind.

The valve travels 6¼″ are longer than specified. In order to reduce same to 6″, a corner notch in each gear has to be plugged, or if a screw reversing gear, the corner stops have to be arranged accordingly.

Plugging a corner notch affects the full gear lead.

The forward full gear lead figured at 7/32″ with reverse lever in the notch which has to be plugged, becomes ¼″ with lever in the new corner notch.

Similarly the back up full gear lead figured up to this time as 3/32″ blind becomes 1/16″ blind. See effect on lead and valve travels by hooking lever up one notch in the early part of chapter.

Don't forget a corner notch may need plugging because of valve fouling a bumping point after making eccentric rod adjustment.

Now is the time to plug the corner notch or clear the part which fouls in steam chest if a "D" Valve.

Compare the 1/16″ lead specified with the lead figured out up till this time and it is seen that in forward gear 3/16″ lead off is required. Back up full gear lead being 1/16″ blind needs ⅛″ lead on.

Figure out as per previous explanation the amount to move each eccentric sheave around the axle. In this case the forward gear 3/16″ lead off amounts to a figurative movement of 9/32″ and the back up ⅛″ lead on, figures out as 3/16″.

The actual movement of the forward gear eccentric sheave measured where it touches the axle is 5/16″ and being a case of lead off, the sheave is moved around the axle in a direction taken by the driving wheel when running back up.

The actual movement of the back up eccentric sheave measured at the axle is 7/32″ bare and being a case of lead on, the eccentric sheave is moved around the axle in a direction taken by the driving wheel when running back up also.

A green hand on valve setting should always make a small lay out after figuring the amount of eccentric sheave movement required in order to get the actual amount required.

Make a note of actual amounts to move eccentric sheaves on axle and in which direction.

Put up main rods.

Take full gear cut offs.

Equalize the full gear cut offs by adjustment of eccentric rod lengths if the difference in cut offs is $1\frac{1}{2}''$ or less and suffer the effect on full gear leads.

Equalize the full gear cut offs by adjustment of the link saddle pin, if the difference in these cut offs is over 2", providing the set of lower rocker arm is in the right direction. Previously explained.

Send reach rod and link lifters to blacksmith to have changes made.

Send eccentric rods to have changes made. Same being equal to the distance as shown at "A" Figure 113, in each case to allow of a turned bolt fit when re-assembling.

Mark and scribe eccentric sheaves both ways as a check before taking down and stepkeying same to obtain the required movement around axle.

When parts are returned to engine, check up to be sure that the changes have been made correctly. Watch out that rod sets and twists are as before.

Replace parts, finish off by tightening nuts and split pinning where required, etc.

If what is known as a full card is required, i.e., the full gear leads, valve travels, cut offs, pre-admission, etc., take the desired information from the engine AFTER all rod changes, etc., have been made including eccentric sheave movements.

NOTE, if full gear travels are correct and equalized by lifter adjustment or by plugging a corner notch in rack in one or both gears, one can figure on equalizing the cut offs by adjustment of the eccentric rods respectively without worrying what effect on cut offs the movement of an eccentric sheave around an axle will have.

IMPORTANT POINTS TO REMEMBER FOR A SWITCH ENGINE

When full gear readings have been taken in the case of a switch engine and there is a figurative reach rod change present, DON'T FORGET to make allowance for same on full gear leads and valve travels on both sides of engine in both gears.

If you equalize valve travels, during your figuring, by a pre-determined change in the length of a lifter, MAKE ALLOWANCE for its effect on full gear lead.

If you plug a corner notch in reverse lever rack to shorten up certain valve travels to prevent valve striking a bump point or to give link block clearance, make allowance for its effect on full gear lead and full gear valve travels as case may be.

The latter three items must be considered before deciding what "Lead On" or "Lead Off" is required to obtain the specified full gear lead in any case.

Bear in mind if the foregoing is adhered to and the cut offs are equalized, don't worry about the cut offs on one side of locomotive proving to be longer than on the other for a given reverse lever position. They will become adjusted when the ACTUAL changes are made to rods, etc., afterwards.

VALVE SETTING ON A FREIGHT OR PASSENGER ENGINE FITTED WITH STEVENSON LINK MOTION

Assume for example that the steam lap of the valve is 1".

Take specified full gear lead in both gears as 1/16".

The specified full gear valve travels 6".

The reversing gear is attached to the boiler at the back end and affects the reach rod 3/8" during boiler expansion.

That boiler is cold when valves are set.

The reach rod is not adjustable and it is not convenient to have the change made until after valves are set.

The full throw of eccentric sheaves is 6".

The diameter of axle where eccentric sheaves are fitted is 9".

The rockers are indirect.

The rocker arms are equal in length.

The reverse shaft upper arm is one and a half times as long as the reverse shaft lifting arms.

That full gear lead is affected 1/32" at each end of cylinder when the reach rod is lengthened or shortened 1/2".

That full gear valve travel is affected 1/4" (i.e., 1/8" at each end) when the reach rod is lengthened or shortened 1/2".

That the notch up valve travel is affected 1/8" (i.e., 1/16" at each end) when the reach rod is lengthened or shortened 1/2".

That motion is assembled except eccentric straps and rods, valves and valve rods.

The pitch of the reverse lever rack teeth and lever catches are such that will allow the reach rod to be moved ½" at each notching as the lever is being hooked up.

Obtain the necessary information for valve setter's report before main valves are put into steam chests, i.e.—

Length and width of steam ports.
Type of valve.
Inside or Outside Admission Valves.
Thickness of valve lip if a "D" Valve.
Whether "Allen" Ported if a "D" Valve.
Thickness of valve seat if a "D" Valve is used.
The steam lap of the valves.
The exhaust clearance, if any, or exhaust lap of valves.
Eccentric sheave full throw, or any other items called for which can be taken at this time.
Blow out steam passages from boiler to steam chest.
Put main valves in.
Put steam chest covers on in the case of piston valves.
Take valve bump marks or danger marks.
Take port marks allowing for valve stem expansion and piston rod volume in the case of "INSIDE ADMISSION VALVES ONLY."
Scribe two small arcs equidistant from the centre of the two port marks to indicate the specified full-gear lead.
Apply loose tin coverings to protect valve stem readings during temporary absence during valve setting.
Put on steam chest covers in the case of "D" Valves at this time.
Blow and clear out foreign matter from the steam ports between valve chests and cylinders.
Put in pistons and connect to crossheads when the piston rod glands, etc., are on the piston rod O.K.
Drive home the cotter through the piston rod and crosshead.
Put up front cylinder heads and nip tight with three or four nuts at least.
Take piston bump marks.
Level the main frames with jacks.
Put up valve rods when valve stem glands, etc., are in position O.K.
Drive home valve rod cotters.
Check up lengths of valve rods and if a change is required, MAKE IT NOW.

Check up reach rod length.

If reach rod is adjustable, plumb the upper reverse shaft arm, when the reverse lever is in mid gear notch, for valve setting purposes and when finished it is a cinch to lengthen the reach rod by adjustment, enough to offset the effects, if any, of boiler expansion.

Assume that our case is shown in Figure 114.

The figurative change for valve setting purposes is shown as ¾" at "C." Make a note of same for reference later. The actual change allowing for ⅜" boiler expansion effect on reach rod is ¾" added to ⅜" which results in 1⅛" lengthening by the blacksmith after all changes have been figured.

Make a note of actual reach rod change.

Put rollers under the main driving wheels properly.

Tighten main driving horn binder bolts and studs.

Set up main driving wedges.

Put up main rods.

Adjust main rod wedges or drive cotters as case may be,

Go over the motion and see that all rocker and reverse shaft brackets are bolted properly and all motion pin nuts, etc., are tight.

Check up the full throw of eccentric sheaves and their approximate position with respect to the main pin. Now is the time to correct an error in this respect.

Put up eccentric straps, tighten strap bolts and see that a complete turn can be made with each easily.

Take out all unnecessary sets and twists from eccentric rods.

Put up eccentric rods and bolt with one bolt in the strap end in the slot hole.

Tighten link pin nuts.

Adjust the reverse shaft balance spring and see that reverse lever can be moved freely in both directions to reach the corner notches.

Place reverse lever in full gear forward notch and see that same is not moved until you see fit or you are ready to take a back up reading.

Turn engine forward and with one complete revolution of the main driving wheels, proceeding as detailed in the case of the switch engine.

Find the four dead centres on the right main driving wheels.

Scribe the piston crosshead travels.

Scribe forward full gear lead lines.

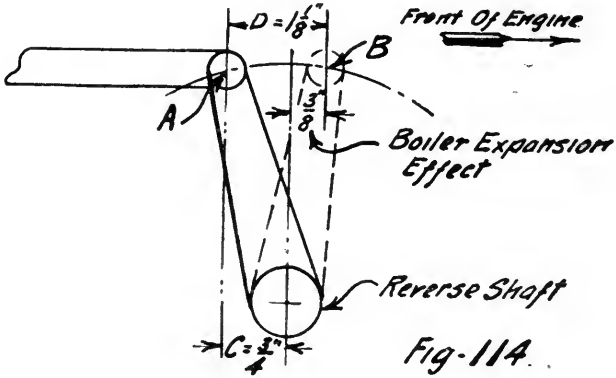


Fig-114.

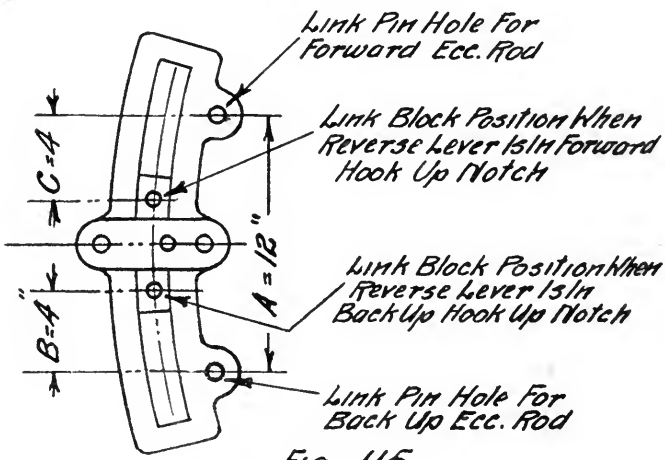

Link Pin Hole For Forward Ecc. Rod
Link Block Position When Reverse Lever Is In Forward Hook Up Notch
C = 4"
A = 12"
B = 4"
Link Block Position When Reverse Lever Is In Back Up Hook Up Notch
Link Pin Hole For Back Up Ecc. Rod

Fig-115

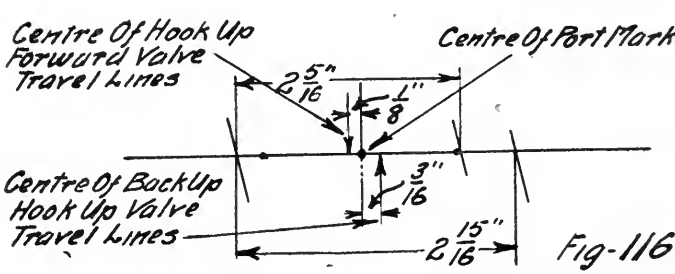


Fig-116

Scribe forward full gear valve travel lines.

Measure link block clearances in forward gear.

Measure slip of the link in forward gear if required by foreman.

See that motion does not foul any other part of engine during a complete revolution.

Take down main rods and adjust for length if necessary so that crosshead travels will occur in the centre of their respective piston bump marks.

Main rods may be left down until required in order to take cut offs.

Place reverse lever in full gear back up notch.

Turn engine back up and with one complete revolution of the main drivers:—

Scribe the back up full gear lead lines.

Scribe the back up full gear valve travel lines.

Measure link block clearances in back gear.

Measure slip of the link in back gear if required by foreman.

See that motion does not foul any other part of engine during a complete revolution.

If it is not known what a given change in the length of a reach rod or lifter affects the full gear lead and full gear valve travels, NOW is the time to find out and make notes on same for reference.

In order to be able to adjust the lengths of eccentric rods from a hook up reading take the proportionate distances of the link and link block at this time as follows:—

Catch the nearest dead centre whilst moving engine in a back up direction and then stop.

Hook up reverse lever in the case of a freight engine about four notches or about 5″ and in the case of a passenger engine about two notches or say around 3″ from the mid gear notch.

Get underneath and measure the distance between the link pin centres as shown at "A" Figure 115. Suppose this is 12″.

Measure also the distance between the centre of link pin and centre of link block pin as shown at "B," Figure 115, suppose this is 4″. Without moving engine, place reverse lever in the forward running notch and measure the distance as shown at "C," Figure 115. Suppose this is 4″. Make a note of these distances for reference later.

Let Figure 94 represent a full gear reading taken to serve for this example, although both sides of locomotive have to be considered.

Adjust the eccentric rod lengths from the full gear readings as explained in the case of a switch engine at this time which means in our example the forward eccentric rod has to be lengthened 3/16" and the back up shortened ¼".

Note down the forward and back up full gear leads from the readings taken, keeping each side of locomotive separate. Our example shows 1/64" blind in the forward and 17/64" lead in back up gear.

Note down the forward and back up full gear valve travels for both sides of locomotive keeping them separate.

Our example shows 5⅝" valve travel in the forward and 6⅞" in the back up full gear.

Clean off the full gear lead and valve travel lines from the valve stems, renew the marking and scribe the straight line once again through the port marks.

The reverse lever being in the forward hook up notch, move engine ahead and scribe the hook up valve travel lines during one turn of the main drivers on both sides of locomotive.

If the effect of a reach rod length change on hook up valve travels is not known, NOW is the time to find it as before explained and make a note of same.

Place reverse lever in the back up hook up notch.

Move engine back up and scribe the hook up valve travel lines for back gear on both sides of engine during one turn of the wheels.

Let Figure 116 represent the hook up reading taken (exaggerated for demonstration) on the same locomotive on the same side after adjustment of eccentric rods has been made from the full gear reading shown in Figure 94.

Adjust the eccentric rod lengths from this hook up reading.

According to Figure 116, the forward eccentric rod requires shortening and the back up eccentric rod is to be lengthened.

Figure 117 shows more clearly the actual adjustment of eccentric rods as before explained.

Allow for the effect of the ¾" figurative lengthening of reach rod on full gear lead, full gear valve travels and hook up valve travels. See Fig. 114.

Forward full gear valve travel taken from reading as 5⅝" figures out as 6".

The back up full gear valve travel taken from reading as 6⅞″ figures down to 6½″.

The forward full gear lead taken from reading as 1/64″ blind figures out as 1/16″ blind.

The back up full gear lead taken from reading as 17/64″ figures out to 5/16″.

The forward hook up valve travel taken from reading at 2-5/16″ figures out to 2½″.

The back up hook up valve travel taken from reading as 2-15/16″ figures out to 2¾″.

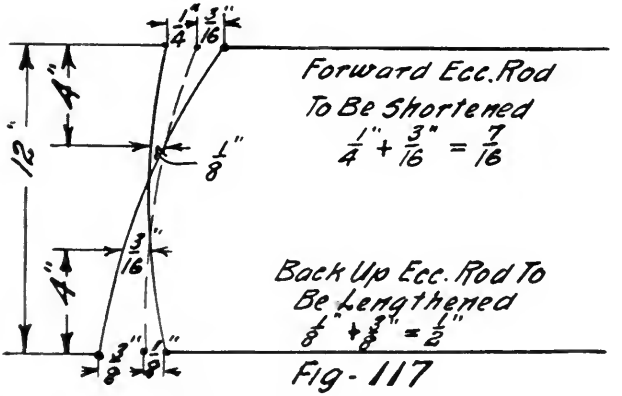


Fig - 117

Determine the link lifter length adjustment required to equalize the hook up valve travels last figured.

The forward 2½″ and the back up 2¾″ will both equal 2⅝″ if the reach rod is lengthened ½″.

The reach rod has been taken care of however, therefore the link lifter has to be lengthened 2/3 of ½″ which amounts to 21/64″ full, owing to the proportionate length of reverse shaft arms. Note down the link lifter change required.

Allow for the effect of 21/64″ full lengthening of link lifter on full gear lead and full gear valve travels.

The forward full gear valve travel last figured at 6″ is brought to 6¼″.

The back up full gear valve travel figured at 6½″ is brought or reduced to 6¼″.

The forward full gear lead figured at 1/16″ blind now becomes 3/32″ blind.

The back up full gear lead figured at 5/16" now becomes 11/32".

If you plug a corner notch in each gear to bring the full gear valve travels to 6" don't forget the effect on full gear lead.

Plugging a notch in our example amounts to the movement of ½" as far as reach rod is concerned.

The forward full gear lead which was figured last as 3/32" blind now is brought to 1/16" blind.

The back up full gear lead which was figured last as 11/32" now becomes ⅜".

Lead specified in full gears is 1/16" therefore to obtain same, the forward eccentric sheave has to move around to give ⅛" lead on and the back up eccentric sheave is moved around to take 5/16" lead off.

Figure out the distance to move eccentric sheaves around the axle in a manner the same as explained in the case of a switch engine.

Having adjusted the eccentric rods from the hook up readings, put up main rods and take the hook up cut offs before making any actual changes to rod lengths, etc.

Finally adjust eccentric rods to equalize the hook up cut offs if less than 2" difference in same is present.

If the difference in hook up cut offs is more than 2", square same by adjustment of link saddle pin.

Make all rod length changes and move eccentric sheaves around the axle the correct amount, stepkeying same for best results.

Keep check on all changes before and after they are made to see if made O.K., including original sets and absence of twists in rods.

If a record of pre-release, pre-admission, etc., is required make all changes including movements of eccentric sheaves before taking the necessary information known as a FULL CARD.

The specifications in one shop often differs considerably from another, but if the methods previously explained are studied carefully no difficulty will be experienced in complying with shop demands.

A valve setter may be called out to square up the eccentric rods from the valve travels in a hurry whilst engine is on the outdoor track. As long as the port marks have been taken properly the engine can be moved slowly giving the valve

setter a fine chance to scribe the valve travels, full gear or hook up as required, in both gears. Eccentric rod adjustment can be made from same.

Important Points to Remember for a Freight or Passenger Engine

In the case of a freight or passenger engine and a reach rod figurative change is present, make allowance for same on full gear valve travels, full gear leads, hook up valve travels and link block clearance.

If by a pre-determined change to a link lifter length you seek to equalize the hook up valve travels, make allowance for this change on full gear lead, full gear valve travels and on the link block clearance.

If a corner notch is plugged make allowance for same on full gear lead. Make allowance on full gear valve travels if link block clearance required compels the plugging of a corner notch.

The aforementioned points must be considered before you can decide how much "Lead On" or "Lead Off" is required to obtain the specified full gear lead.

Chapter VII.

WALSCHAERT VALVE GEAR

THERE is a type of reversible valve gear, largely used to-day, known as the "Walschaert Valve Gear."

The "Walschaert Valve Gear" is an outside motion, i.e. the source of the valve motion as well as the valve gear lies on the outside of the main frames of a locomotive.

A Crude Engine

To obtain a clear idea of this motion, let us revert to a crude engine, similar to figure 1 and shown in Figure 118. It is easily seen that the engine is non-reversible, explained in chapter 1. A valve is used having no steam lap, no lead, no exhaust clearance nor exhaust lap.

An inside admission valve is represented at "G" and an Indirect rocker shaft at "K."

The source of valve motion is set up by an eccentric crank pin "A" supported by an eccentric crank arm which in turn is securely fastened to the end of the main crank pin "B," same being represented in Figure 118.

The eccentric rod "C" connects with the lower rocker arm at "D."

The valve rod connects with the upper rocker arm at "E."

The valve being Inside Admission and with due respect to the position of eccentric crank pin in relation to the main pin, it is evident that this one way engine moves in the direction indicated by the arrow "H." Note in this case, when the centre line of valve stem "J" is produced backwards, that it passes through the centre of rocker shaft "K."

If the engine was required to run in the direction indicated by arrow "L," then same could be effected by connecting the valve rod "F" to the point "N" instead of to "E" thus forming a direct rocker, see Figure 119.

When valve rod is connected to rocker arm at "E," the engine will operate in one direction and when connected to "N" operates the opposite way.

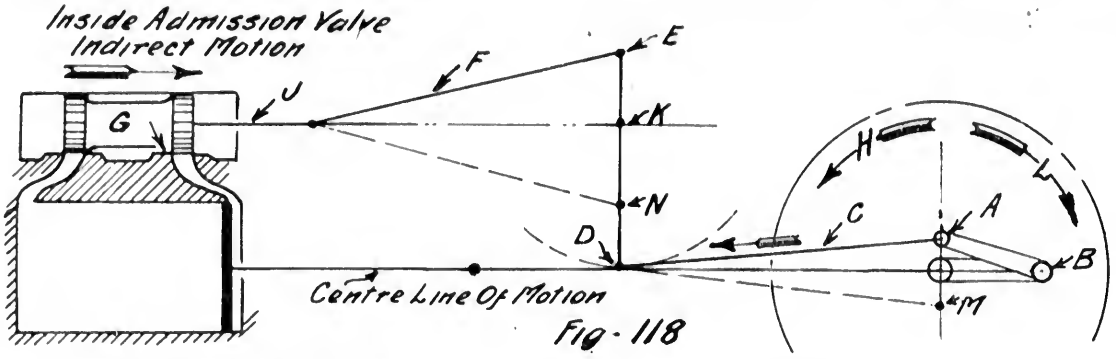


Fig - 118

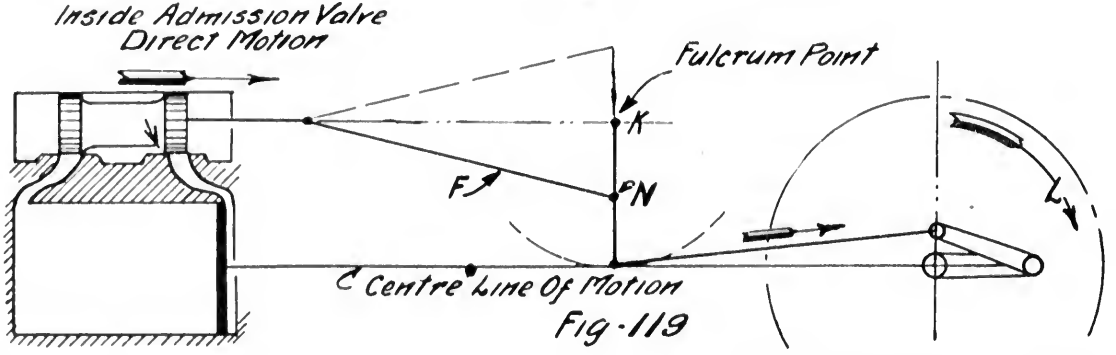


Fig - 119

A Crude Reversible Engine

Egide Walschaert conceived an idea whereby a suitable arrangement of rods, etc., was made so that the back end of valve rod could be passed from point "E" to point "N" at will without breaking a connection, thus arriving at a reversible gear.

The indirect rocker "EKD," see Figure 118, is replaced by a link and the rocker shaft now becomes known as the link fulcrum. See Fig. 120.

The valve rod "F," Figure 118, is arranged to carry a link block which fits in the slot of the link. The valve rod now becomes known as the radius rod.

The radius of the link is equal to the valve rod distance "W.V.," see Figure 120.

The radius rod is extended beyond the link, in this case, and is moved up and down by a radius rod lifter as shown at "O."

The reverse lever "T" is connected to the reverse shaft upper arm "Q" by the reach rod "S."

The lower or lifting reverse shaft arm "P" connects with the radius rod lifter "O."

The reverse lever is shown in mid gear position. In this position the centre of link block coincides with the centre of the link fulcrum at the point "V," Figure 120. If the engine is moved around at this time, there would be no movement of the valve or radius rod.

Direct and Indirect Motion

When the reverse lever is placed in forward gear, the radius rod is dropped below the link fulcrum and a direct motion is in evidence. When in back gear an indirect motion is obtained.

The eccentric rod connects with the link at "D." Once the eccentric crank pin is set O.K. its full throw remains the same. When the eccentric rod length is adjusted and the engine is operating, the point "D" called the link foot has a continuous unvarying oscillating movement.

Radius Rod Length

Again with these adjustments O.K. and the main pin spotted on a dead centre, see Figure 120, the valve remains dead when the reverse lever is moved from the forward to the back up corner notches, if the radius rod length is correct.

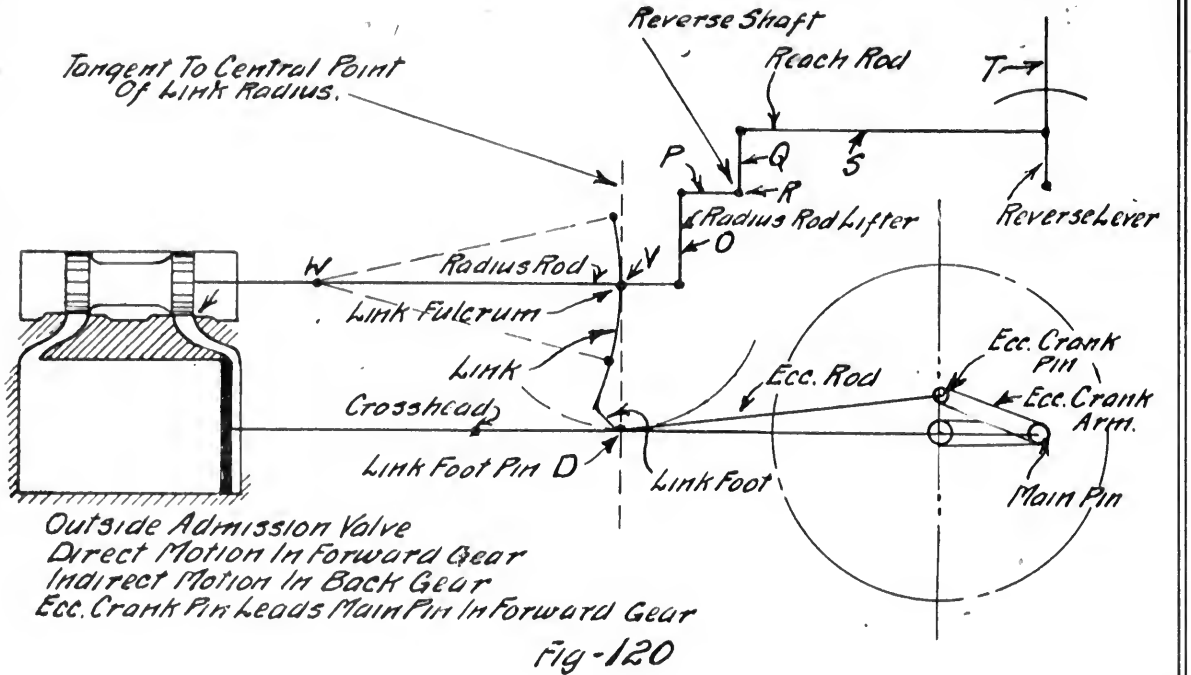

Reverse Shaft
Reach Rod
T
Tangent To Central Point Of Link Radius.
P
Q
S
R
Radius Rod Lifter
O
Reverse Lever
W
Radius Rod
V
Link Fulcrum
Link
Ecc. Crank Pin
Ecc. Rod
Ecc. Crank Arm.
Crosshead
Link Foot Pin D
Link Foot
Main Pin
Outside Admission Valve
Direct Motion In Forward Gear
Indirect Motion In Back Gear
Ecc. Crank Pin Leads Main Pin In Forward Gear

Fig-120

Long Valve Travel

When the reverse lever is placed in forward or back up full gear positions and the engine is operated the valve gets a full gear travel known as the "Long Travel of the Valve."

Variable Valve Travel

The valve travel is variable dependent on the position of the reverse lever. The valve has no "steam lap," which means that admission of live steam and exhaustion of same respectively occurs during the entire stroke of the piston.

Note in Figure 120, the centre of the link foot pin occurs on a line shown dotted which is a tangent to the link radius from the centre "V" of the link fulcrum.

Lay Out Considerations

On some engines the radius rod in forward gear is dropped below the link fulcrum, see Figure 121. On others in forward gear it is raised above, see Figure 122.

On some engines the eccentric crank pin leads the main pin in forward gear, see Figures 120 and 122. On others it follows the main pin in forward gear, see Figures 121 and 123.

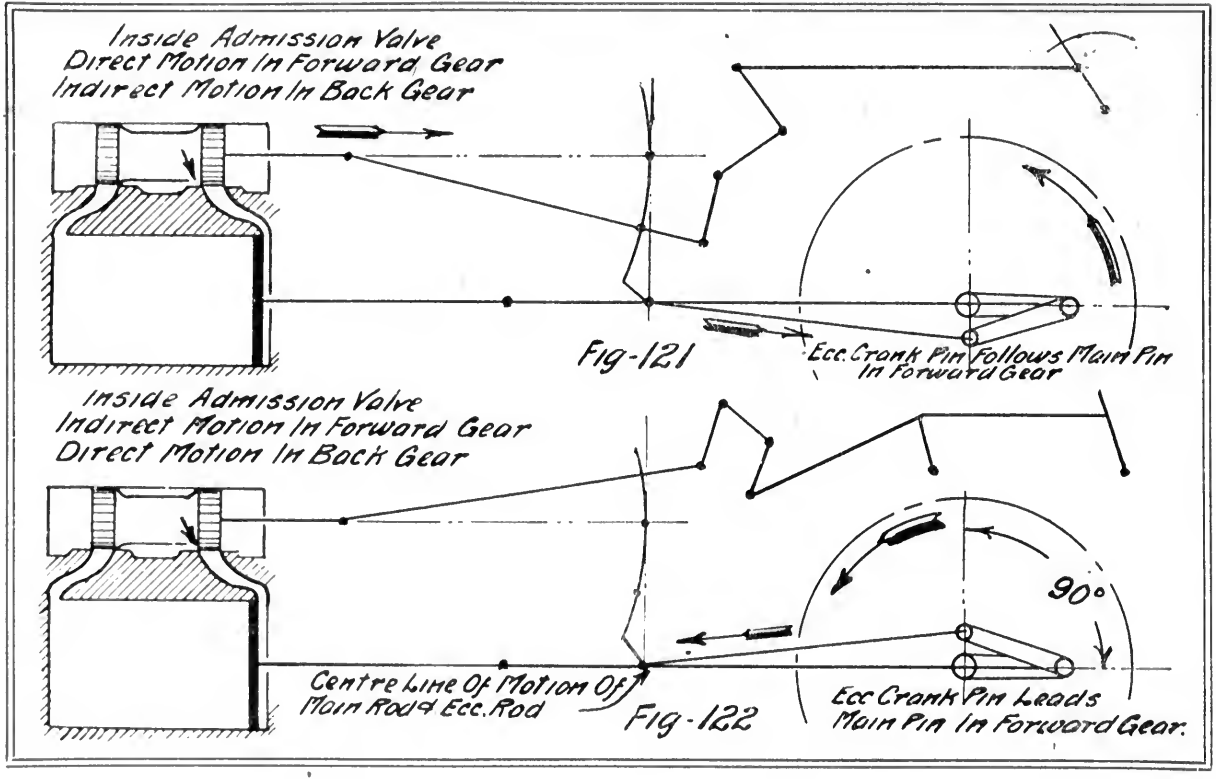
Again the point of connection between the radius rod and the radius rod lifter often occurs ahead of the link fulcrum instead of behind same.

The aforementioned items, however, depend on the lay out of the valve gear and owing to the many designers of Walschaert Valve Gear, there is no common standard lay out accepted.

If uncertain as to whether the eccentric crank pin follows or leads the main pin, work back from the valve, considering if same is "Inside" or "Outside" Admission, also noting whether the motion is "Direct" or "Indirect" in forward gear. Imagine the main pin on a dead centre and thus arrive at the approximate relative position of eccentric crank pin to the main pin.

Back Set of Link Foot Pin

The back set of a link foot pin in the case of Walschaert Gear is determined by the designer and must not be tampered with by a valve setter. An explanation why a link foot pin is back set is ventured, although same does not enter into a


Inside Admission Valve
Direct Motion In Forward Gear
Indirect Motion In Back Gear
Fig-121
Ecc. Crank Pin Follows Main Pin
In Forward Gear
Inside Admission Valve
Indirect Motion In Forward Gear
Direct Motion In Back Gear
90°
Centre Line Of Motion Of
Main Rod & Ecc. Rod
Fig-122
Ecc Crank Pin Leads
Main Pin In Forward Gear.

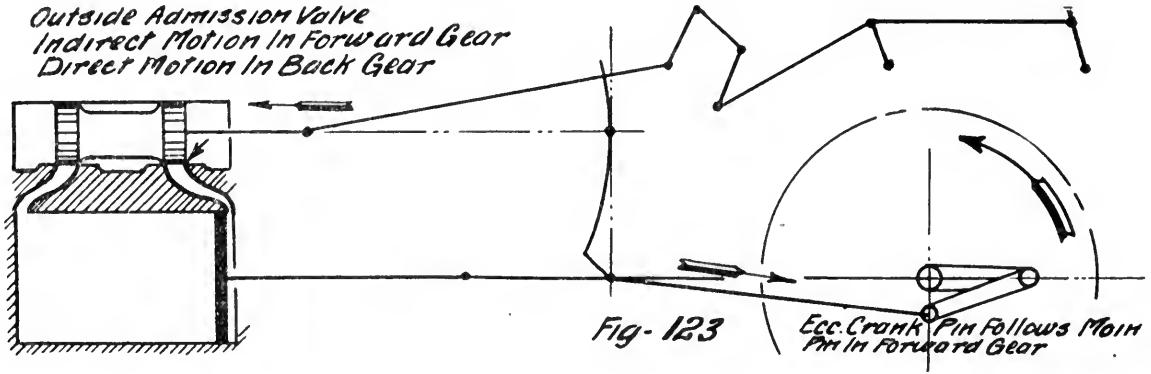

Outside Admission Valve
Indirect Motion In Forward Gear
Direct Motion In Back Gear
Ecc. Crank Pin Follows Main Pin In Forward Gear

Fig - 123

valve setter's province, yet, it is necessary at this time to prevent a possible misunderstanding.

Figure 124, represents a link and link foot pin. The centre of link foot pin is shown at "A." A dotted line is shown tangent to the link radius. This tangent passes through the centre of the link fulcrum.

If the eccentric rod is connected to the point "B" on the tangent instead of at "A," the link would move through unequal angles on either side of central position.

The designer finds the point "A" which will allow the link to move through equal angles as seen in Figure 124.

The distance between the two parallel lines passing through "A" and "B" respectively is called the "Back Set of the Link Foot Pin."

Centre Line of Motion

The centre line of motion of the main rod also for the eccentric rod is shown in Figure 122.

When the link foot pin occurs above the centre of the main driving axle, the centre line of motion of the eccentric rod occurs as shown in Figure 125.

Eccentric Crank Pin Leading or Following Main Pin

The centre of eccentric crank pin must occur on a line which passes through the centre of axle and at right angles to the centre line of motion of eccentric rod. See "A.B.," Figure 125. This accounts for the eccentric crank pin being less than 90° ahead of or more than 90° behind the main pin in forward gear dependent of course on the lay out of the valve gear.

Steam Lap and Lead Arrangements

Steam lap is given to the valve to obtain an engine economical on fuel consumption, etc. A longer full throw is given to the eccentric crank pin to obtain full port openings in full gear.

A means whereby to overcome the steam lap of the valve and to give lead is arranged in a different manner as compared with Stevenson Link Motion. Refer back to Figure 120.

The radius rod connection with valve stem at "W" remains stationary no matter how or where you move the reverse lever, when engine is on a dead centre. It is at this time when lead is required. The means employed to obtain same is shown in Figure 126, an "Inside" admission valve being represented.

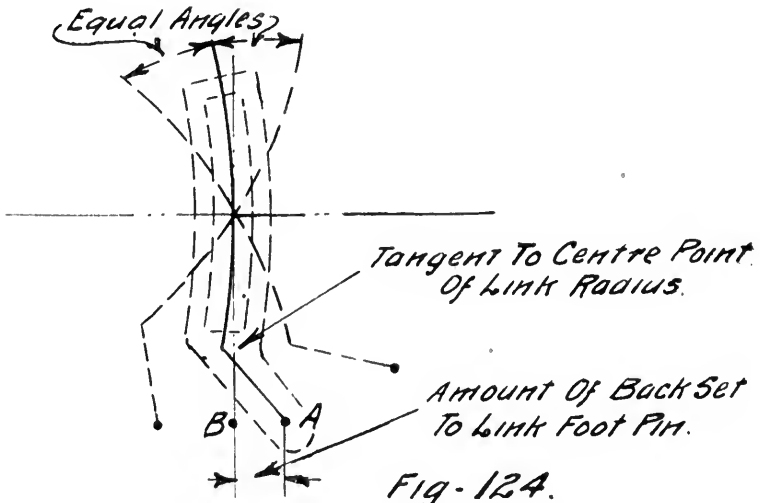

Equal Angles
Tangent To Centre Point
Of Link Radius.
Amount Of Back Set
To Link Foot Pin.
B
A

Fig - 124.

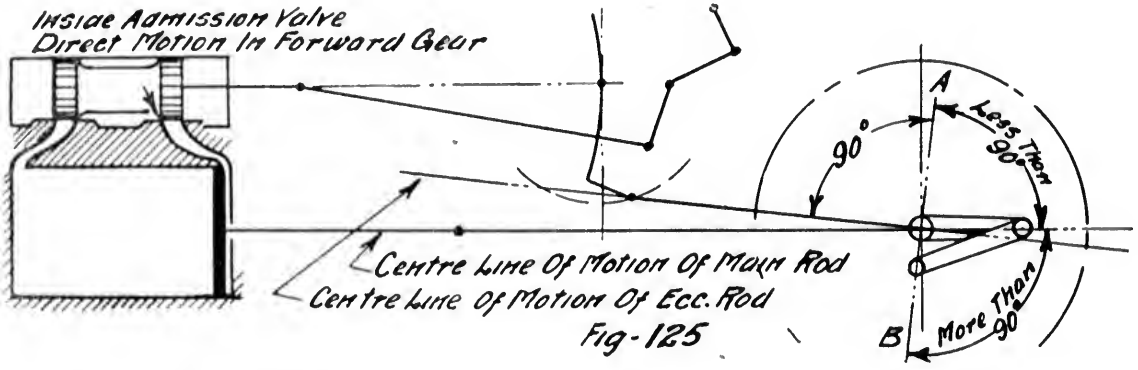

Inside Admission Valve
Direct Motion In Forward Gear
Centre Line Of Motion Of Main Rod
Centre Line Of Motion Of Ecc. Rod
90°
A
Less Than 90°
More Than 90°
B

Fig-125

The valve is on the centre of its seat.

The main crosshead is in the centre of its stroke or travel.

A lever "A.C." called a combination lever has three connections.

The end "W" of the radius rod, Figure 120, connects with combination lever at "A," Figure 126.

The valve stem connection occurs at "B" and the crosshead union link connects at "C."

The crosshead is arranged to connect with Union link at "D."

All these connections allow of movement of the parts.

Figure 127 shows the main crosshead drawn backwards to the extreme end of its travel.

The point "A" acts as a fulcrum point in this position when main pin is on a dead centre and the "Inside" admission valve is moved backwards to give lead to the valve because the proportions of the combination lever together with the arrangement of the layout allows of same.

It is readily seen that the same lead is affected at the front port when the crosshead arrives at the extreme front end of its travel.

How to Determine whether Inside or Outside Admission Valves

The radius rod connection with the combination lever is seen to occur above the valve stem connection in the case of "inside" admission valves.

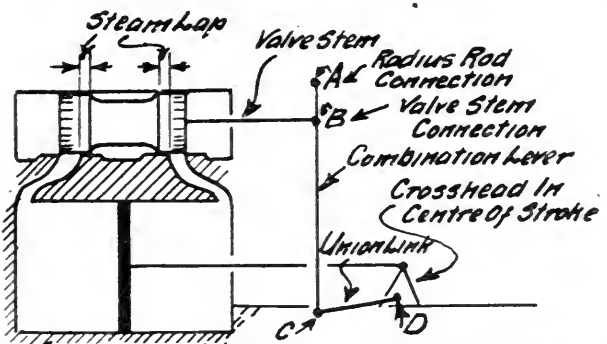
In the case of "outside" admission valves this radius rod connection occurs below the valve stem connection, see Figure 128. The proportions and layout are arranged, however, by the designer to obtain the lead required.

Combination Lever Back Set

Sometimes a designer arranges a back set to the lower part of the combination lever, see Figure 129. The reason in most cases is to suit the construction of the other parts of the locomotive. One simply has to follow the blue print requirements.

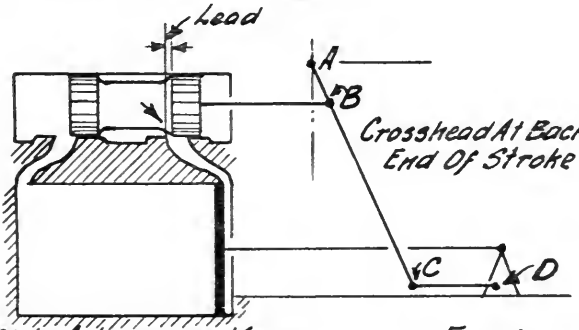
Short Valve Travel

The main crosshead is the direct source of the motion which gives lead to the valve in Figures 127 and 128. This is sometimes called the "Short Travel" of the valve and is equal to the sum of twice the lap and twice the lead. The combination



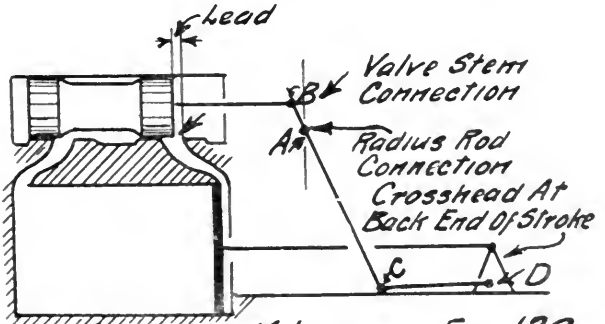
Inside Admission Valve
Valve Placed Centrally With Ports

Fig-126



Inside Admission Valve

Fig-127



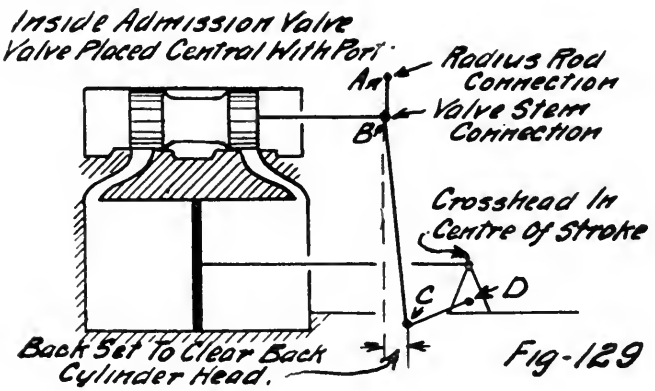
Outside Admission Valve

Fig-128

of the "short travel" and the "long travel" of valve is made when the combination lever is connected to the radius rod, see Figure 130.

Constant Lead

This means when main pin arrives at a dead centre and the link is in a central position that the lead is obtained by reason of the travel given to the valve by the crosshead, independent of the position of reverse lever. Sweep the reverse lever at this time the full length of its rack and no valve movement results.



The lead therefore remains the same for every reverse gear position and is said to be constant.

When main piston and crosshead are in the centre of the stroke, the valve would be central as shown in Figure 126, if it were not for the eccentric crank pin which has acted upon the valve to insure a full port opening in full gear operation.

The full gear position seen in Figure 130 shows the lead required and the link in its central position.

Spot the main pin on a working quarter and move the reverse lever from one corner notch to the other and the long travel of the valve is the result approximately which generally insures a full port opening in the forward and back up full gears.

When hooking up a reverse lever with a "Stevenson Link Motion" the valve travels are shortened but the lead is

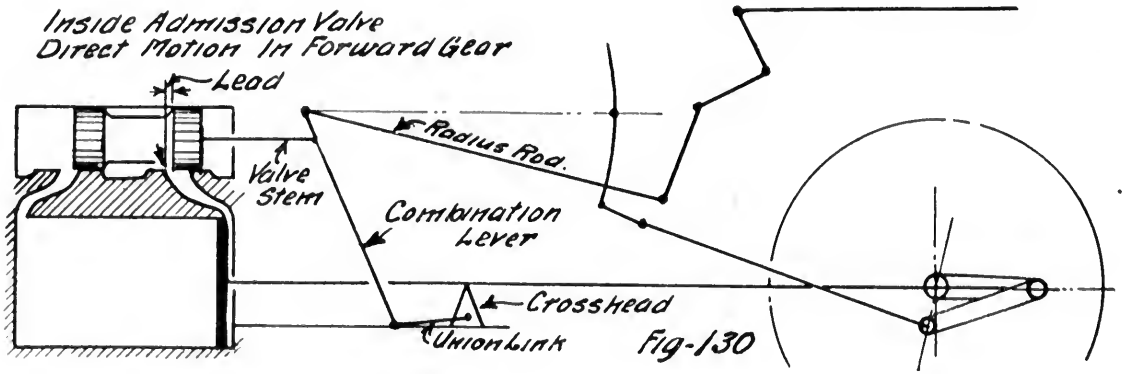

Inside Admission Valve
Direct Motion In Forward Gear
Lead
Radius Rod.
Valve Stem
Combination Lever
Crosshead
Union Link

Fig-130

increased, whereas in the case of Walschaert Gear the valve travels are shortened but the lead remains the same.

The valve travels being variable, the cut offs are variable although the lead remains constant.

If the lay out of a Walschaert Valve Gear is good and the valve setter sets the eccentric crank and adjusts the length of the eccentric rods and valve stems to obtain equal and constant lead one would naturally expect the cut offs to be practically equal, i.e., within ¾" of difference.

It is good policy however, to always try the cut offs with the reverse lever in the working or running notch after having squared the lead by adjustment aforementioned.

The Slip of the Link Block

The slip of the Link Block in the link is greatest in full gear and is reduced as the reverse lever is hooked up nearer to the mid gear notch.

Full Gear Valve Travels

Owing to the slip of the link block, one finds that the valve travels on either side of the centre of the valve seat are often widely different. The difference is most pronounced in full gear. Full gear travels are taken however to see whether a full port opening is obtained, also as a check with the valve bump marks to see if valve properly clears the valve chamber.

Exhaust Clearance, etc.

Exhaust Clearance of a valve, and Exhaust Line and Line are used to advantage with valves operated by Walschaert Valve Gear.

A valve setter checks the amount of exhaust clearance for shop reports only, unless a further detailed report of pre-releases and exhaust cut offs are called for, in which case he would lay out the port marks for same in a manner similar to that explained in the case of Stevenson Link Motion and obtain the information required.

Valve Events

The valve events such as "Admission," "Cut Off," "Expansion," etc., occur on an engine with "Walschaert Valve Gear" in a manner similar to those explained in the case of Stevenson Link Motion.

The valve gears are widely different by comparison but similar valves are used for both.

Chapter VIII.

WALSCHAERT VALVE GEAR. VALVE SETTING DETAILS.

Port Marks.

PORTMARKS are taken in the case of a Walschaert Gear in exactly the same manner as before detailed for Stevenson Link Motion, allowing for valve stem expansion and piston rod volume in the case of "Inside Admission Valves" only.

Port marks may be taken on valve stems if convenient for readings.

A bracket or plate is generally used however, a provision for which is made to fasten same securely rigid to the valve stem crosshead. This plate presents the opportunity to scribe a line on same parallel to the line of travel of the valve to take the readings on, same being removed after valve setting operations are over. It is up to the valve setter to see that this bracket or plate is properly fastened in the first place.

Valve Bump Marks.

Valve bump marks are taken in the same manner as in the case of Stevenson Link Motion, except that the aforementioned plate may be used. This is done before eccentric rods are connected.

Piston Bump Marks.

Piston Bump Marks are taken in the same way as detailed for Stevenson Link Motion, except that the piston rings are removed from pistons before putting same into the cylinders for the bumps.

After Bump Marks are taken the pistons are drawn, their rings replaced for safekeeping and pistons are left out during valve setting to save dragging them back and forth unnecessarily.

Some workers do not put the pistons in the cylinders to take the bump marks.

By careful measurement of pistons and cylinders they place the crossheads to take the bump marks respectively.

In some cases this latter method is fairly reliable, but in others it is doubtful. Taking the actual bumps is most sure.

Reach Rod Adjustment.

Reach rods nowadays in the case of Walschaert Gears are adjustable. The main frames are levelled for valve setting, in which case, when reverse lever is placed in mid gear notch, the reach rod or rods as the case may be, can be adjusted until the reverse shaft arms stand just as the blue print calls for.

This is necessary owing to the various shapes and angles of reverse shaft arms on the various engines.

Radius Rod Lifter Length Adjustment.

To check up radius rod lifter lengths, adjust reach rod length as just detailed. Place reverse lever in the mid gear notch. Set the combination lever plumb. If the combination lever has a back set to it, plumb the top end of same. This can be done approximately by spotting crosshead in the centre of its stroke with union link connected. Set each link plumb as shown in Figure 131, if the line drawn through link fulcrum centre and the centre of point of connection between radius rod and combination lever is horizontal. If this line is not horizontal, rather elevated instead, then set the link at right angles to same as in Figure 132.

The distance between the inside top of link and the top of link block shown at "C" Figure 131, also the distance between the under side of link block and the inside bottom of link shown at "D" Figure 131 should conform to the blue print requirements. Sometimes these distances are equal and sometimes unequal.

Again by swinging the link back and forth there should be no movement to the valve stem or radius rod at this time.

If the distances are not O.K., i.e., the link block centre does not coincide with the link fulcrum centre, get the radius rod lifter adjusted, accordingly, at this time and replace same. Treat both sides of engine in the same manner.

Putting Rollers Under.

When putting rollers under the main drivers for setting the valves of an engine with Walschaert Gear, do so in exactly the same manner as for Stevenson Gear, paying particular attention to the equalizing of side play between main drivers and both main frames, the tightening of main driving horn binder bolts, and the setting up of main driving wedges.

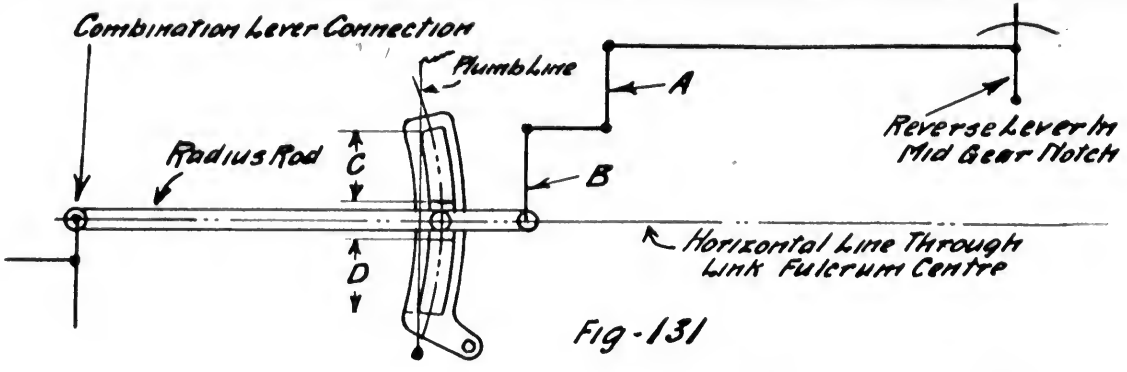


Fig - 131

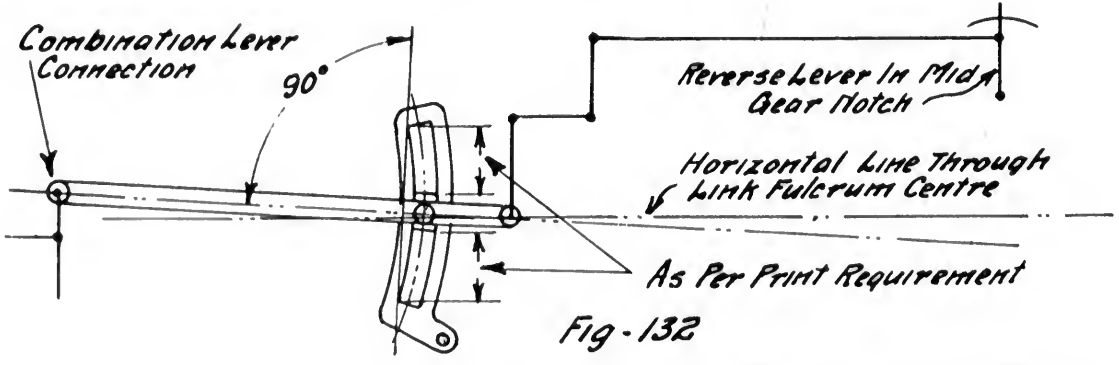

Combination Lever Connection
90°
Reverse Lever In Mid Gear Notch
Horizontal Line Through Link Fulcrum Centre
As Per Print Requirement

Fig - 132

Eccentric Crank Arm Approximate Setting.

Eccentric crank arms are jarred around the main pins into their approximately correct positions and nipped tight with temporary bolts.

These positions can be determined by reference to the blue print for same, or by tracing back from the valve as before explained in chapter 7.

Eccentric Rods.

Try eccentric rods for unnecessary sets or twists, and remove any if present. The link foot pin should tap in nicely when making this connection, with the eccentric crank pin end properly connected.

Dead Centres.

Dead Centres are found in a similar manner to that explained for Stevenson Link Motion.

Main Rod Adjustment.

Owing to the effect of crossheads on the valve motion, adjust the length of main rods as soon as the main crosshead travels are taken, and replace main rods. This occurs before any valve readings are taken.

Eccentric Crank Arm Setting Proper.

Catch the dead centre shown at "C" Figure 133.

The eccentric rod being up, place one point of a tram of convenient length, in the centre of link foot pin and scribe a small arc "A" with the other point of tram on a bar or bracket, so as to cut a horizontally scribed line as shown at "B" Figure 133.

Go ahead and catch the other dead centre shown at "D" by dotted lines. Again place one point of tram in the centre of link foot pin and with the other tram point scribe another small arc as shown at "E."

If the two arcs "A" and "E" coincide, i.e., "A" occurs exactly in the same place as "E," then the eccentric crank arm is set O.K.

If, however, the two arcs occur apart, jar the eccentric crank arm in direction to obtain the desired result, i.e, until the second tram point reaches a point nearly half way between the two arcs.

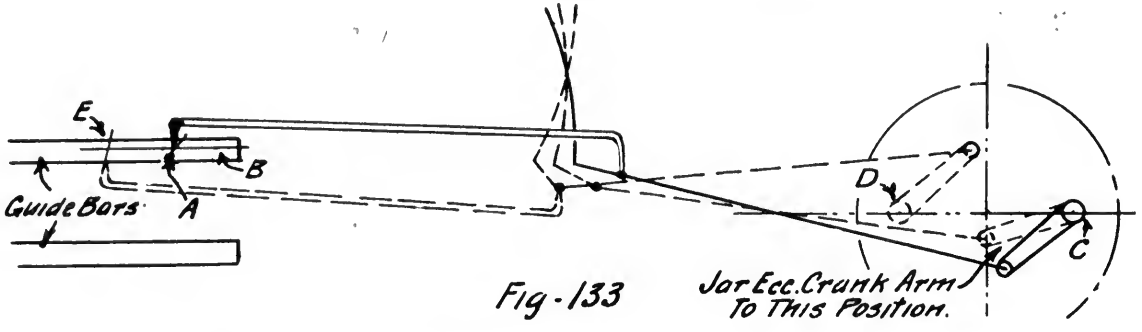


Fig - 133

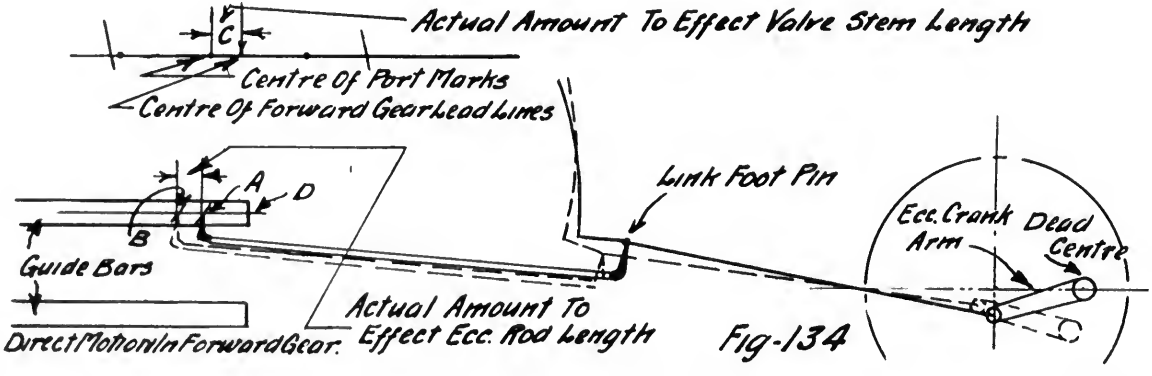


Fig - 134

Go ahead, catch the aforementioned dead centres again, and scribe with tram as before to be sure you have obtained the desired setting.

Always tighten up on temporary bolts after jarring eccentric crank arms with a copper hammer.

It is policy to mark an eccentric crank arm with a fine sharp chisel with respect to the main pin as a check on any further relative movement after setting same.

Others mark off the eccentric crank arm dowel holes at this time.

A Method of Squaring Lengths of Eccentric Rods and Valve Stems.

The following method of setting the lengths of eccentric rods and valve stems is used in some shops.

Let it be said, however, that same will not apply correctly unless the lay out of the valve gear is good.

After the eccentric cranks, etc., are set as per previous explanations just given, in this chapter, catch a dead centre as shown in Figure 134.

Move the reverse lever back and forth through the entire length of its quadrant.

If valve does not move the eccentric rod length is O.K. If valve moves proceed as follows:—

Check up the length of radius rod and if correct, take a tram of convenient length and place one point in centre of link foot pin. With the other tram point scribe an arc, see "A" Figure 134, on a guide bar or bracket, which is convenient for same.

Scribe a horizontal line through this arc as seen at "D" Figure 134.

Now move main drivers around carefully with all slack taken up until link arrives at a position where valve does not move when reverse lever is moved through the entire length of quadrant, and then stop.

Apply the tram again to centre of link foot pin and scribe another arc as seen at "B" Figure 134.

The distance between "A" and "B" along the horizontal line is the amount of change to make to eccentric rod length, In the case shown, eccentric rod has to be lengthened. Make the change right away.

Now catch a dead centre properly and re-check by reverse lever movement, to see if eccentric rod length is O.K.

Some workers go as far as taking one lead line only, whilst on this dead centre, making allowance for specified lead between the lead line and the nearest port mark and any difference shown, they affect the valve stem length accordingly.

It is good policy however, even with this method to scribe the two leads lines and find the centre of same, see Figure 134.

The distance between the centre of port mark and the centre of lead lines, see "C" Figure 134, is the amount of change to make in the valve stem length. In the example shown in Figure 134, according to the rule of bringing centre of port marks to centre of scribed lines, the valve stem needs shortening the amount shown.

Some shops favor changing radius rods length in preference to the valve stem length, if the amount of change is ¼" or less, to save pulling the valves out.

A Sure Method of Squaring Eccentric Rod and Valve Stem Lengths to Lead Lines.

A method more sure, to use in squaring up eccentric rod and valve stem lengths, after eccentric crank has been set, lifter lengths and reach rod lengths adjusted, is as follows:—

For example, take the case of a switch engine.

Figure 135 represents a reading of forward and back up full gear lead lines.

It is seen that the centre of the forward lead lines "A" is 1/8" ahead of the centre of port marks.

The centre of back up lead lines "B" is ¼" behind the centre of port marks.

Find the centre point "C" between "A" and "B," with a pair of dividers.

The distance between "A" and "B" being 3/8" the point "C" would have to come ahead 3/16" to reach the centre "A" of the forward lead lines.

It is seen in Figure 136 if the valve stem connection has to come ahead 3/16" that the radius rod connection to combination lever has to move ahead a little more. This is owing to the proportions of the combination lever.

Locomotives in service to-day are such that one can be governed in all cases for "inside" admission valves to increase

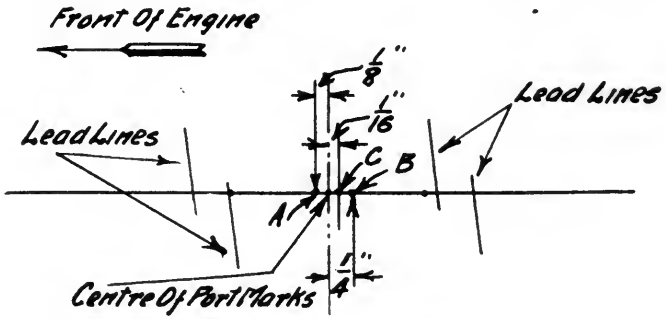


Fig-135

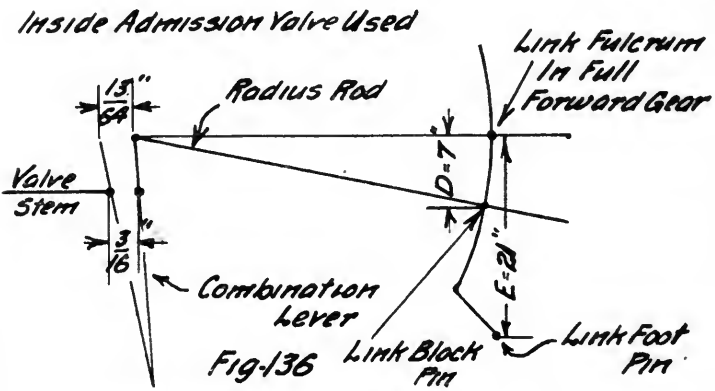


Fig-136

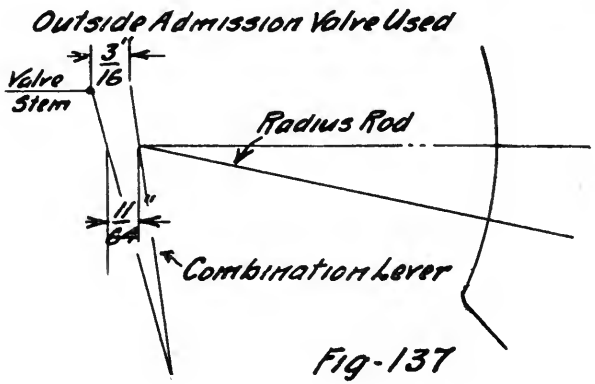


Fig-137

this distance (3/16" in our example), 1/12 of itself, in other words, this 3/16" chosen for example has to be figured at 13/64".

In all cases of "outside" admission valves, this distance would have to be decreased 1/12 of itself. In our example the 3/16" would be figured as 11/64", see Figure 137.

Another proportion has to be figured on before the final alteration required is arrived at.

When the last lead line is taken for instance in forward gear, the reverse lever is in the corner notch, and the distance between the link fulcrum centre and the link block centre is to be measured. Suppose this measures 7" as shown at "D" Figure 136.

Measure the distance between the link fulcrum centre and the centre of link foot pin. Suppose this measures 21" shown at "E" Figure 136.

The proportion is 7 to 21, or 1 to 3.

This means with direct motion in forward gear that the eccentric rod has to be lengthened three times 13/64", which equals 39/64".

This proportion does not apply to all cases, but has to be found by measurement when taking a lead line.

Lead lines are taken on a passenger engine with the lever in the corner notch, but the cut offs are taken and squared with lever in the hook up position. The changes required are taken at the valve stem and then the valve stem readings can be figured out along the same lines as a switcher, but the proportion of "D" to "E," shown in Figure 136 might prove upon measurement to be 3 to 21 or 1 to 7, which would mean, if 13/64" was figured from the combination lever proportion that the actual change to eccentric rod length would be seven times 13/64", or equal to 1–27/64". The aforementioned is arranged to suit the demonstration.

Let us get back to our switch engine calculation.

The eccentric rod change made at once will cause "C" Figure 135 to become the common centre of the forward and back up lead lines.

This point "C" is still 1/16" behind the centre of port marks.

In order to bring the centre of port marks to the common centre "C" of lead lines, the valve stem has to be shortened in this case 1/16", i.e., the exact amount measured on the reading.

When the valve stem length is changed and the port marks are re-taken, one finds that the common centre of lead lines falls in the same spot as the centre of port marks.

The rule for the aforementioned setting is:—

Bring the centre of the two centres of forward and back up lead lines to the centre of the forward lead lines and consider whether the motion is direct or indirect, in forward gear, in order to determine whether to lengthen or shorten the eccentric rod.

Bring the centre of port marks to the centre of the two centres of the forward and back gear lead lines to determine required change of valve stem length.

Adjustable Eccentric Rods.

To save time in some shops, an adjustable pair of eccentric rods are provided for each class of engine in which case, after valve setting is completed, the pair of eccentric rods intended for service on the engine can be made the exact length according to results the adjustable pair obtained.

Again, cut offs can be tried before valve stem lengths are changed.

Make the common centre "C" Figure 135, of the centre of the forward and the centre of the back up lead lines, the new centre of port marks. The new port marks can be laid off with a pair of dividers and centre popped, hammering out or disfiguring the original port marks to prevent mistakes.

If the new port marks are used don't forget the actual valve stem length change already known, which has to be made together with any further change which may be necessary when squaring the cut offs.

One can almost hear the question "Why go to all this trouble when eccentric rods and valve stems can be adjusted so easily the same as before detailed in this chapter" ?

The answer to this is owing to the many lay outs of "Walschaert Valve Gear" on engines now in service it is a good policy for the valve setter to play "Safety First," unless he receives definite instructions as to the method of valve setting to be used from the foreman of the shop.

Squaring the Cut Offs.

A close approximate method of finally squaring eccentric rod and valve stem lengths to the cut offs, on all classes of

engines equipped with "Walschaert Gear" is as follows:—

Assume that a switch engine has been squared up to the lead lines and the cut offs have been taken.

Figure 138 shows the front and back cut offs in the forward and back full gear on one side of a locomotive.

First add the back and front cut offs in forward gear together 25½" and 22¼" equals 47¾".

Add the back and front cut offs in back gear together 22¾" and 23½", equals 46¼".

Take the smallest from the largest.

In this our case take the back gear from the forward gear, 47¾" less 46¼" equals 1½".

Halve this difference 1½", which results in ¾".

Take this result ¾" from each of the front and back cut offs whose sum was the largest, in this our case, the forward gear. The front cut off "A" 25½" becomes 24¾", see "B." The back cut off "C" in forward gear 22¼" becomes 21½", see "D."

The foregoing has simply equalized the sum of the forward and the sum of the back up cut offs figuratively.

The front cut off in back gear is shown at "E" as 22¾", and the back cut off in back gear is seen at "F" as 23½".

In order to determine change to make in eccentric rod length, take "D," which is the smallest of the back cut offs in both gears from the largest back cut off "F," i.e., 21½" from 23½", gives a difference of 2".

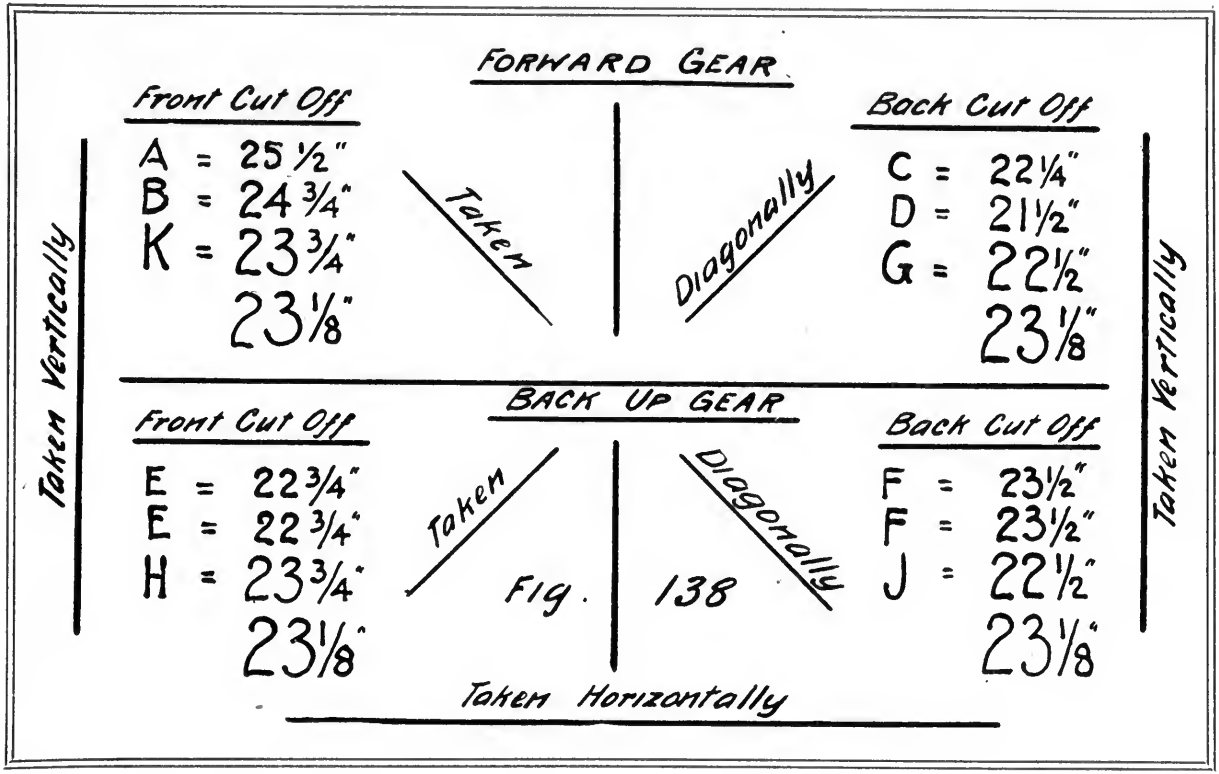
Halve this difference, 2", which results in 1".

The eccentric rod has to be altered in length an amount which will affect the cut offs all round favorably, to equalize the two back cut offs and the two front cut offs respectively. (Explained later in this chapter).

Suppose the alteration in eccentric rod length is made, the back cut off in forward gear "D" equal to 21½" is brought to 22½", see "G."

If you move diagonally in figure 138, the back gear front cut off "E," which is 22¾", becomes 23¾", see "H."

The alteration to the eccentric rod affects all the cut offs on that side of locomotive. This means that the back gear


FORWARD GEAR
Front Cut Off
A = 25 1/2"
B = 24 3/4"
K = 23 3/4"
23 1/8"
Taken
Diagonally
Back Cut Off
C = 22 1/4"
D = 21 1/2"
G = 22 1/2"
23 1/8"
Taken Vertically
Taken Vertically
BACK UP GEAR
Front Cut Off
E = 22 3/4"
E = 22 3/4"
H = 23 3/4"
23 1/8"
Taken
Diagonally
Back Cut Off
F = 23 1/2"
F = 23 1/2"
J = 22 1/2"
23 1/8"
Fig. 138
Taken Horizontally

back cut off "F" which now is 23½" becomes 22½", see "J," and moving diagonally in the sketch the forward gear front cut off "B" now 24¾", is reduced to 23¾", see "K."

When an eccentric rod length is changed and a cut off at one end of cylinder is lengthened, the cut off at other end of cylinder in the same gear is shortened.

Take note also that when an eccentric rod length is changed to lengthen a front cut off in one gear that the front cut off in the opposite gear is shortened.

In other words, when considering changes to be made in eccentric rod lengths, together with the layout as in Figure 138, similar changes occur when considered diagonally, and opposite changes occur when considered horizontally or vertically.

You will note as far as we have gone that the two front and the two back cut offs in each gear respectively have been equalized figuratively, see "K" and "H," also "G" and "J."

In order to determine changes to make in valve stem take a short cut off from a long one in our case, "G" is 22½" taken from "K," which is 23¾", leaves 1¼".

Halve this difference 1¼", which results in 5/8".

Tack on this 5 8" to the short cut offs "G" and "J," bringing same up to 23⅛".

Take away this 5/8" from the long cut offs "H" and "K," reducing same to 23⅛".

With an inside admission valve and direct motion in forward gear the eccentric rod has to be shortened an amount to increase the back cut off in forward gear 1".

Also the valve stem will have to be shortened an amount to increase the length of the back cut off in forward gear 5/8".

If this work is done with average care the cut offs will be practically equal in both gears when the reverse lever is placed in the full gear positions.

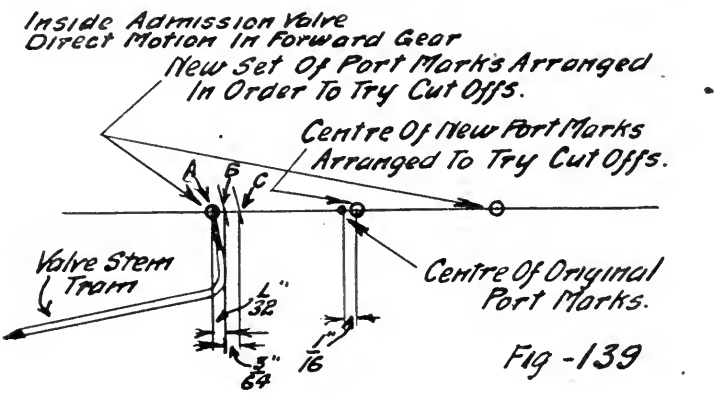
This method can be applied to cut offs taken in the hook up notches on a freight or passenger engine.

To determine how much alteration is required in the lengths of eccentric rod and valve stem, select the cut off which has to be lengthened by the eccentric rod change also by the valve stem change. In our case it happens to be the back cut off

"C" in the forward gear, Figure 138. Move drivers forward to take slack out of the valve motion with the reverse lever in the forward corner notch, in this our case of a switch engine. Pick up the back cut off "C" at 22¼" and stop engine. The engine has been stopped when the valve stem tram point just dropped into the centre pop "A" Figure 139, which is a port mark.

Move drivers around in forward direction until 1" is added to the back cut off and stop, i.e., the crosshead is now 23¼" from the beginning of its stroke.

Scribe an arc "B" on the reading with the valve stem tram.



Move drivers around again in a forward direction until another 5/8" is tacked onto the back cut off in forward gear, then stop. The crosshead is now 23–7/8" from the beginning of its stroke.

Scribe another small arc "C" on the reading plate with the valve stem tram.

To consider the amount of alteration in the length of eccentric rod one has to figure the proportion of "D" to "E" Figure 136, in this example, 7 is to 21.

The rule of bringing the port mark to the tram line holds good and in this case of direct motion, in forward gear, the eccentric rod has to be shortened, three times the distance between "A" and "B" Figure 139, or 3/32" if "A" is 1/32" from "B." If the eccentric rod length change were made at

this time, and new port marks were taken one of them would occur at "B."

The amount of alteration in the length of valve stem is the exact distance between "B" and "C" shown in Figure 139 as 3/64". To determine whether to lengthen or shorten valve stem this amount, imagine you can hold "C" in one hand and bring the point "B" to it. This means shortening of the valve stem 3/64".

If it is required to try the cut offs with the last changes made, before releasing the engine, make the eccentric rod change right away, and if inconvenient to change the valve stem lengths at this time, lay off the port marks, one of which will be made at "C" Figure 139.

This method, as in all other cases of squaring by the cut offs in one calculation, is approximate only, and there may be an occasional class of engine blow along where, after the calculation is made, and the changes arranged accordingly, a matter of a difference of ¾" to 1", will. occur in the cut offs which you aimed at equalizing.

In cases where exceptional slip of the link block in link occurs, where the extent of the full gear valve travels are widely different, although the lead may be squared up in the first place, the above difference mentioned will crop up if a big alteration is to be made.

If squaring up a freight or passenger engine by the cut offs, the proportion of the distance between the link block centre and link fulcrum centre as compared with the distance between the link foot pin centre and the centre of link fulcrum must be considered when figuring the eccentric rod length change.

The aforementioned example is somewhat exaggerated to render it more clear.

Important Points to Remember with Walschaert Valve Gear.

Although there are certain methods employed in some shops to set the valves quickly on engines equipped with Walschaert Valve Gear, be governed by the shop rules.

It pays one to be careful, however, owing to the many designers who have different ideas as to what is really considered good practice in the layout of the valve gear.

Unless ordered to pursue a particular shop practice by the foreman of the shop, it is good policy on the first engine of a new class or on a strange engine, to consider the following important points.

Before attempting to take a valve stem reading, check up the valve gear according to blue print requirements, adjust the length of reach rod or rods as the case may be, adjust the lengths of radius rod lifters and main rods, also set the eccentric crank arms properly and bolt them securely, to prevent same moving on main pin during the remainder of the valve setting.

Take full gear valve travel lines to enable you to check up full port openings in full gear and the clearance of the valves from the valve bump marks later on, when changes have to be made in the lengths of the eccentric rods and valve stems.

Figure the first changes required in the length of the eccentric rods and valve stems from lead lines taken with the reverse lever in the corner notches respectively.

The first eccentric rod changes are made as soon as determined and before trying the cut offs.

Figure the final changes to eccentric rod and valve stem lengths from the cut offs, i.e., in the case of a switch engine, from the full gear cut offs. In the case of a freight or passenger engine from the hook up or running cut offs.

Check lead collectively for valve setting purposes in a similar manner to that used for Stevenson Motion.

Check lead separately for shop report, after changes have been made to square the cut offs.

If the cut offs prove to be practically equal after the lengths of the eccentric rods and valve stems have been adjusted from the full gear lead lines on an engine of a certain class, then all other engines of that class may be squared to the full gear lead lines as detailed in this chapter, and let go without trying the cut offs.

Chapter IX.

VALVE SETTING ON AN ENGINE FITTED WITH "WALSCHAERT VALVE GEAR"

WHEN about to set the valves on a switch, freight or passenger engine equipped with "Walschaert Valve Gear" proceed as follows, unless otherwise ordered by the shop foreman.

Before putting in main valves take the information required for shop report and make notes accordingly, as in the case of "Stevenson Link Motion."

Blow out steam passages from boiler to steam chests.

Put main valves in.

Put on steam chest covers in the case of piston valves.

Take port marks. Allow for valve stem expansion and piston rod volume in the case of "INSIDE" ADMISSION VALVES ONLY.

Find the centre between port marks and prick pop same. Port marks to be taken on valve stems if convenient, if not, put up plate brackets on valve stem crossheads and fasten them rigidly to the latter.

Take valve bump marks.

Put on steam chest covers in the case of "D" valves.

Protect port marks with thin sheet metal coverings hung on loosely.

Blow through and clear steam passages from steam chests to cylinders.

Put in pistons without piston rings and cotter up properly to crossheads.

Put up cylinder heads.

Take piston bump marks.

Piston bump marks are often taken by careful measurement without putting pistons in.

If pistons are put in cylinders to obtain piston bump marks, take them out after having obtained same and replace piston rings in pistons for safe keeping.

Level up main frames by jacking same.

Adjust reach rod length or lengths if more than one are used.

Adjust radius rod lifter lengths at this time.

Put rollers under properly, blocking spring gear, etc., being particularly careful when equalizing side play on the main drivers.

Tighten up main driver binder bolts.
Set up main driving wedges.
Put up main rods.

Spot eccentric crank arms approximately correct and nip tight with temporary bolts.
Set eccentric rods sidewise, remove any twists necessary.
Put up eccentric rods.

The correct setting of links, link fulcrums, and their brackets, radius rods, combination levers and union links, are taken care of by the fitter who erects the valve gear, yet it is good policy to check up with blue print the lengths and location of same, also to try out for twists and sets in rods.

Before taking the readings, tighten up all motion pin nuts, adjust main rod wedges, drive all cotters home, etc.
Place reverse lever in the forward corner notch.
Find the four dead centres on the right main driving wheel.
Scribe crosshead travels, when passing each dead centre respectively.
See that valve gear does not foul during a complete revolution.
Adjust main rod lengths at this time.
Replace main rods.
Set eccentric cranks correctly, marking off the dowel pin holes as a check and bolt tight with temporary bolts.
Scribe forward full gear lead and valve travel lines.
Measure link block clearances.
Measure slip of link block in link if required.
Place reverse lever in back up corner notch and with one turn of the main drivers.
Scribe back up full gear lead and valve travel lines.
Measure link block clearances in back gear.
Measure slip of link block in link if required.
See that valve gear does not foul during this complete revolution.
Any fouling that occurs clear at this time.

Check lead collectively and if not as specified, re-check the steam lap of the valve, the width of and distance between the steam port edges, also the proportionate lengths of combination lever and union link and the proper location of union link connection to crosshead. Check up the back set of combination lever lower end if present, and the correct setting of eccentric crank arm.

Determine changes required to eccentric rod and valve stem lengths.

If adjustable eccentric rods are used for valve setting, adjust eccentric rods right away, if not, get the eccentric rods adjusted for length at this time by the blacksmith, checking same before and after the change is made.

Note down the valve stem length changes and make new port marks in order to try cut offs.

Check up valve travels to see if full port openings occur in full gear, also if valve will clear the valve bump marks when changes are made.

Take the Cut Offs in both gears with the reverse lever in the service or running notches respectively, i.e., for a—

Switch engine, in the corner notches.

Freight engine, with reverse lever about six inches from mid gear notch.

Passenger engine about four inches from mid gear notch.

Determine further changes to eccentric rods and valve stems from the cut offs taken.

Make the final change to eccentric rods.

Make the change to valve stem lengths, considering the first changes determined from the lead line reading.

Check before and after final changes are made. IMPORTANT

Drill the dowel holes in main pin and eccentric crank arms, drive the dowels, ream and bolt as required.

In the case where boiler expansion affects the valve gear, lengthen the reach rod to allow for same.

Some valve setters prefer to take the lead lines in the case of a freight or passenger engine with the reverse lever in the hook up notches respectively in order to determine the valve stem length and eccentric rod length changes required. The cut offs on some engines prove O.K. when handled in this manner which means one has to be guided by their experience with each class of engine.

If the lead, port openings, cut offs, etc., are required in shop report, make all changes necessary, FIRST, and take that which is required afterwards.

Approximate Adjustment of Length of Eccentric Rods and Valve Stems

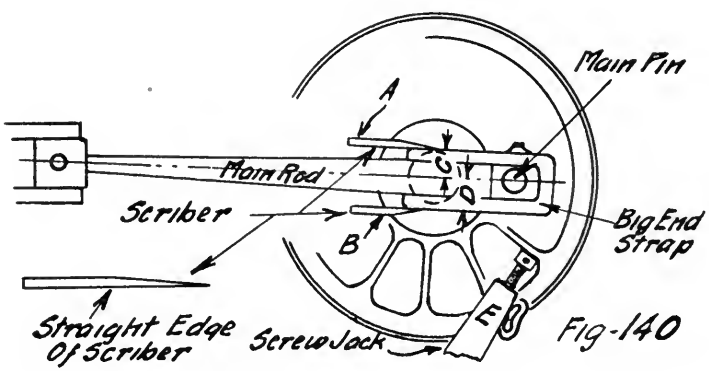
Each side of locomotive may be treated respectively as follows:—

Spot the main pin as nearly as possible on the back dead

centre. This may be done by moving engine slowly ahead, until a dead centre is nearly reached.

Stop the wheels with a block of wood or a chain placed on the rail.

Use a special scriber with a straight edge to scribe two lines across the ends of or near to the end of driving axle as shown at "A" and "B" Figure 140.



Measure the distance "C" to see if it equals the distance "D." If not, apply a jack (to slip the driving wheels) as shown at "E" until "C" equals "D," both being measured from the centre of driving axle.

This is in order if "C" and "D" are equal when measured from the centre line of main rod to the outside faces of big end strap. If otherwise, allow for same, when jacking driving wheels and measuring from centre of axle to the scribed lines.

The eccentric crank arms are generally dowelled to main pin and as this method is applicable to a hurry up job, don't monkey with the re-setting of eccentric crank arms which belongs to the back shop.

If eccentric crank arms must be set, do it right and put rollers under engine, etc.

Move reverse lever back and forth the full length of its rack, when main pin is on this dead centre.

If valve does not move the eccentric rod is O.K. for length.

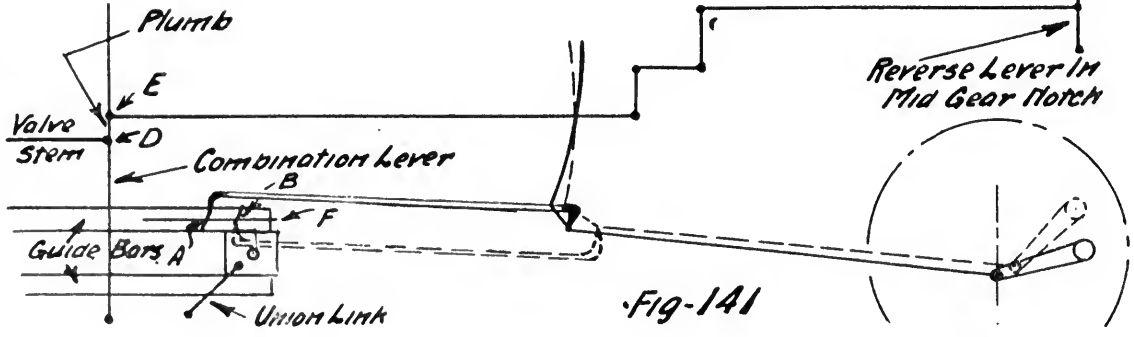

Plumb
E
Valve Stem
D
Combination Lever
B
F
Guide Bars
A
Union Link
Reverse Lever in Mid Gear Notch

Fig-141

If the valve moves take a tram of convenient length, place one point in centre of link foot pin, and with other tram point, scribe an arc, see "A," Figure 141, on a guide bar for instance. Scribe a horizontal line "F" to cut the arc.

When moving reverse lever note which way to move wheel to bring the link into a position where valve will remain dead during the reverse lever movement. Move wheels (slip them with a jack) ahead or back up as the case requires, until the valve becomes stationary, during reverse lever movement, and then stop.

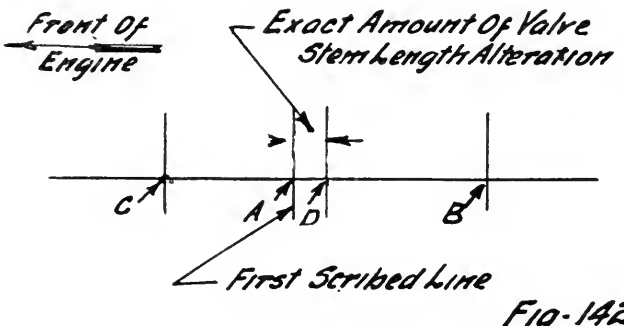


Fig. 142.

Place tram point in centre of link foot pin again, and with other tram point, scribe another arc "B" to cut the straight line "F." The distance between "A" and "B" is the amount of alteration to make in the length of eccentric rod. To bring the first arc to the second means shortening the eccentric rod in this case.

Whilst engine is in this last position, spot reverse lever in mid gear notch and disconnect the combination lever from the union link. Move the combination lever into a position where the part "D.E.," Figure 141 stands at right angles to the line of travel of the valve as shown.

(Sometimes the lower end of combination lever is back set).

Scribe the valve stem at the packing gland represented at "A," Figure 142.

In cases where peep hole plugs can be removed, the combination lever can be moved over each way until valve is on the "point of admission," and the valve stem scribed again for each end respectively and shown at "B" and "C.," Fig. 142.

If a case of "D" Valve, set the brakes on the locomotive.

Open cylinder cocks.

Open steam throttle valve somewhat, i.e., just crack it to allow a little steam to reach steam chests after brake is set.

Move bottom end of combination lever over ahead gradually until steam escapes from the front cylinder cock, then stop. ("Inside Admission Valve" taken for example).

Scribe valve stem at the packing gland.

Move bottom end of combination lever over in a backward direction until steam is seen to escape from the back cylinder cock in about the same volume as that which escaped at the front cylinder cock, then stop.

Scribe valve stem again at the packing gland.

In either of the two cases, whether peep hole plugs are removed to advantage or not, suppose "A," Figure 142, was the first line scribed on the valve stem and "B" and "C" the second and third lines scribed on same. Find the centre of "B" and "C" shown at "D." The distance between "A" and "D" is the amount of alteration to make in the length of valve stem.

To bring the centre "D" of port marks "B" and "C" to the scribed line "A" means lengthening the valve stem an amount equal to the distance between "A" and "D" in this our case of "Inside Admission Valves."

When the aforementioned principles are grasped one finds a position is reached by means of which much unnecessary labor can often be saved dependent on the lay out of the valve gear to a certain extent.

Chapter X.

BAKER VALVE GEAR

THERE is a type of reversible valve gear applied to locomotives called the "Baker Valve Gear."

This gear was originally used on traction engines but later applied to locomotives and became known as the "Baker-Pilliod Valve Gear."

Certain improvements were made, the outcome of which was the present up to date "Baker Locomotive Valve Gear."

A combination lever and union link are used in this gear to overcome the steam lap of the valve and to give a constant lead in a manner similar to that which obtains in the "Walschaert Valve Gear."

There are only two standard designs of "Baker Valve Gear," one applicable to all engines with outside admission and one to all engines with inside admission valves.

The combination lever proportions are arranged however to suit each class of engine, dependent on the steam lap of the valve, the lead specified and the throw of the main driving crank pin.

Owing to the fact that one manufacturer only, having determined for both standards, that the eccentric crank pin shall follow the main pin in forward, and lead the main pin in back up gear, one can be assured that this will occur in ALL CASES.

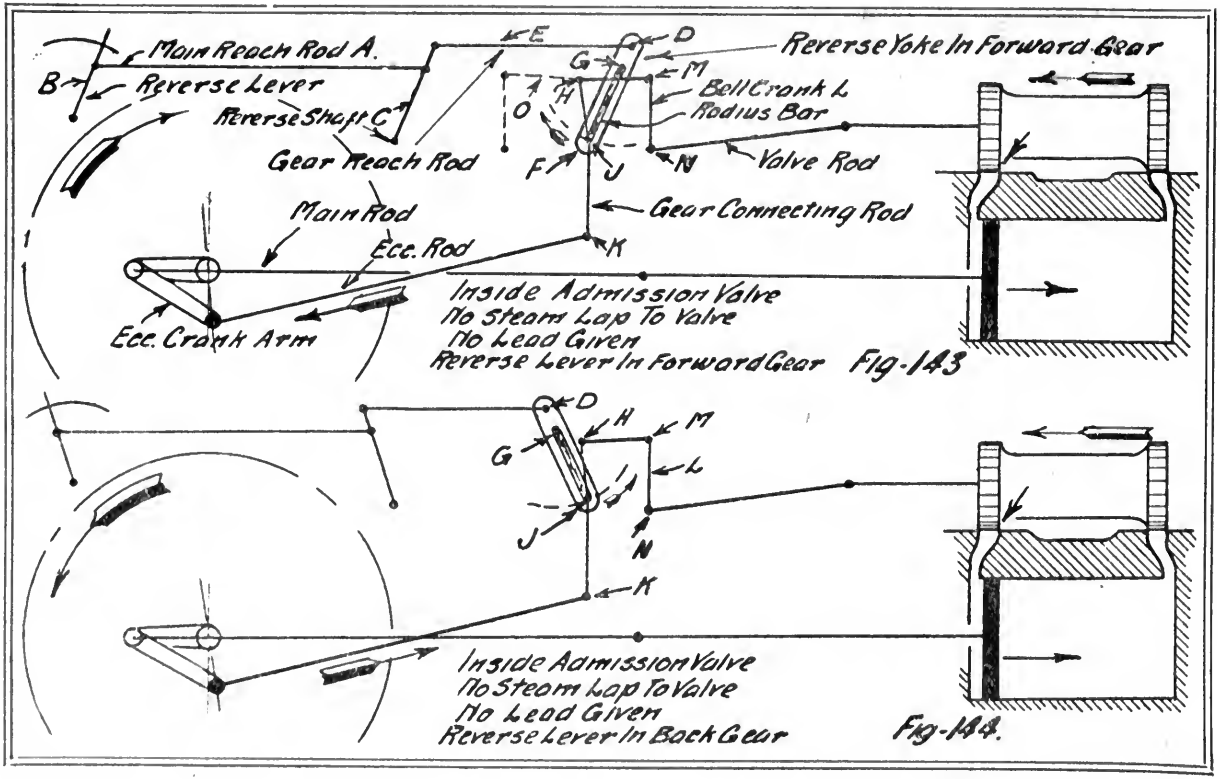
This gear is an outside motion, i.e., the source of the valve motion is at the eccentric crank pin which lies outside the main frames.

The sketches for this gear are made out of proportion to facilitate an easy understanding. Let us start in with a valve having no steam lap and with no arrangement made to give lead, yet otherwise operated in a manner similar to the "Baker Valve Gear," see Figure 143.

One side of locomotive is shown with reverse lever in forward full gear.

An inside admission valve is represented.

The main reach rod "A" connects with the reverse lever "B" and with the reverse shaft arm "C."


Main Reach Rod A.
B
Reverse Lever
Reverse Shaft C
Gear Reach Rod
Main Rod
Ecc. Rod
Ecc. Crank Arm
E
D
G
M
H
O
F
J
N
K
Reverse Yoke In Forward Gear
Bell Crank L
Radius Bar
Valve Rod
Gear Connecting Rod
Inside Admission Valve
No Steam Lap To Valve
No Lead Given
Reverse Lever In Forward Gear
Fig-143
I
L
Inside Admission Valve
No Steam Lap To Valve
No Lead Given
Reverse Lever In Back Gear
Fig-144.

The reverse shaft has two arms, one for each side of locomotive which are connected to the reverse yokes as at "D," by two short reach rods as shown at "E" called Gear Reach Rods.

Each reverse yoke moves about its lower end or fulcrum pin as at "F."

The direction in which the engine moves depends on the position the reverse yoke is placed in.

Note the position of the reverse yokes in forward gear.

The radius bars move about their own fulcrum pins as shown at "G" on the reverse yokes.

The lower end of each radius bar connects with a gear connecting rod as at "J."

The gear connecting rods are practically floating levers.

The eccentric rod connects with the lower end of gear connecting rod as at "K."

The upper ends of gear connecting rods connect with the bell cranks as at "H."

The bell crank "L" has a fulcrum point at "M" and is connected to the valve rod at "N."

In the example chosen of an "Inside Admission Valve," note how the upper arm of bell crank extends from the fulcrum point in a direction away from the cylinders.

In the case of outside admission valves the upper arm of bell crank extends from its fulcrum point in a direction toward the cylinders as shown by the dotted lines at "O."

If it is considered that the valve motion is direct when the valve moves in the same direction as the eccentric rod at all times and indirect when they move in opposite directions, then it may be said—

With "Inside Admission Valves" in forward gear the motion is "Direct" and in back gear "Indirect."

With "Outside Admission Valves," the motion is "Indirect" in forward gear and "Direct" in the back up.

It will be readily seen that as far as we have gone, the eccentric pin is the only source of motion to the valve and it causes what is known as the "Long" travel of the Valve.

If the engine is moved around in a forward direction, from the position shown in Figure 143, the lower end "K" of Gear connecting rod is drawn backwards.

Suppose for a moment that the point "H" is a fulcrum point then the point "J" moves backwards.

The radius bar having a fulcrum point at "G" on the reverse yoke, its other end "J" has to sweep upwards as well as backwards in the path of an arc shown by the dotted line sweeping from "J."

This movement causes the gear connecting rod to push the upper bell crank arm upwards thereby moving the lower bell crank arm, incidentally giving movement to the valve and opening the back steam port.

There is no link used in this type of valve gear.

Figure 144 shows the reverse lever in full back gear.

When engine moves in the back up direction the eccentric rod pushes "K" ahead.

The point "J" moves ahead but upwards as well, owing to the radius bar having its fulcrum point at "G."

The gear connecting rod rises taking the point "H" of the Bell Crank upper arm with it, incidentally moving the valve which is connected by a valve rod to the lower arm of bell crank. The back port is thus opened up.

It is unnecessary to detail steam distribution again with this gear. Each valve gear is designed with one goal in sight, i.e., to obtain an ideal service and steam distribution.

In this case insofar as chosen, a Baker Valve Gear, with valves having no steam lap nor lead given, the valve events such as admission and release occur during the entire stroke and causes a wasteful engine. The valve events are similar to those explained, with valves having no steam lap nor lead given in the case of "Stevenson Link Motion" and "Walschaert Valve Gear."

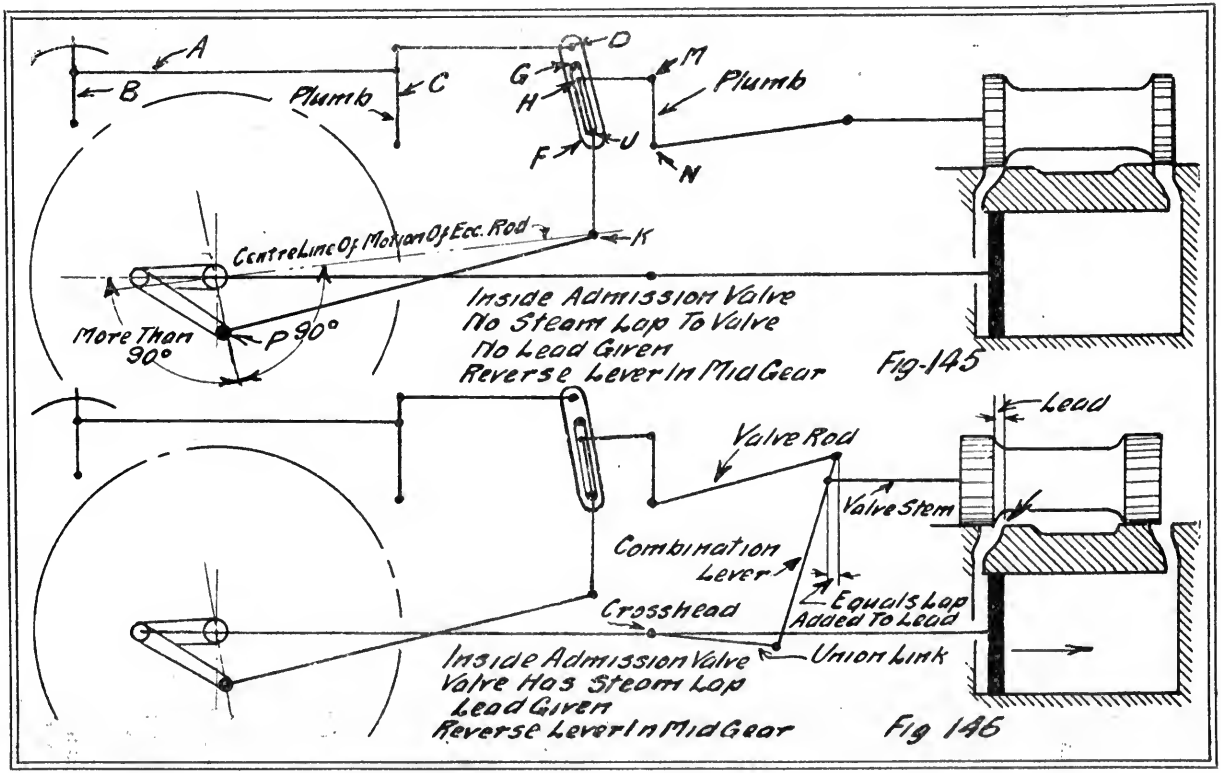
As the reverse lever is hooked up towards mid gear the valve travels are shortened.

Figure 145 shows the reverse lever in the mid gear notch.

Note that the lower bell crank arm in this position is plumb when the main frames are level.

The engine can be turned a complete revolution with reverse lever in the mid gear notch with practically no movement to the valve.

The reason is because the length of the radius Bar "G.J." is so nearly equal to the length of the upper part "J.H." of the gear connecting rod, that no appreciable movement is caused to the bell crank when engine is moved around.


A
B
Plumb
C
D
G
H
F
J
M
Plumb
N
K
Centre Line Of Motion Of Ecc. Rod
More Than 90°
P 90°
Inside Admission Valve
No Steam Lap To Valve
No Lead Given
Reverse Lever In Mid Gear
Fig-145
Lead
Valve Rod
Valve Stem
Combination Lever
Equals Lap Added To Lead
Crosshead
Union Link
Inside Admission Valve
Valve Has Steam Lap
Lead Given
Reverse Lever In Mid Gear
Fig 146

Note that the centre of reverse yoke fulcrum pin practically coincides with the centre of connection at "J" (which connects the radius bar to the gear connecting rod) when main pin is on a dead centre.

In this position the reverse lever can be swept through the whole length of its rack without giving movement to the valve.

It is seen in Figure 145 that the point "K" (where eccentric rod connects with gear connecting rod) lies above the centres of main driving wheels.

The centre line of motion of the eccentric rod is thus elevated.

The centre of eccentric crank pin must occur on a straight line which passes through the centre of main driving axle at right angles to the centre line of motion of eccentric rod.

This accounts for the eccentric crank pin centre being more than 90° behind the main pin in forward gear see "P," Figure 145.

Steam lap and lead being necessary to the valve for shorter and economical cut offs, etc., same are introduced with the combination lever arrangement to take care of them, see Figure 146.

When main pin is placed on a dead centre in Figure 145 and reverse lever is moved through the length of its rack and no movement of the valve occurs it follows that the lead which is given by the combination lever, etc., will remain constant no matter which notch of the rack the reverse lever is placed in, when all parts are adjusted properly.

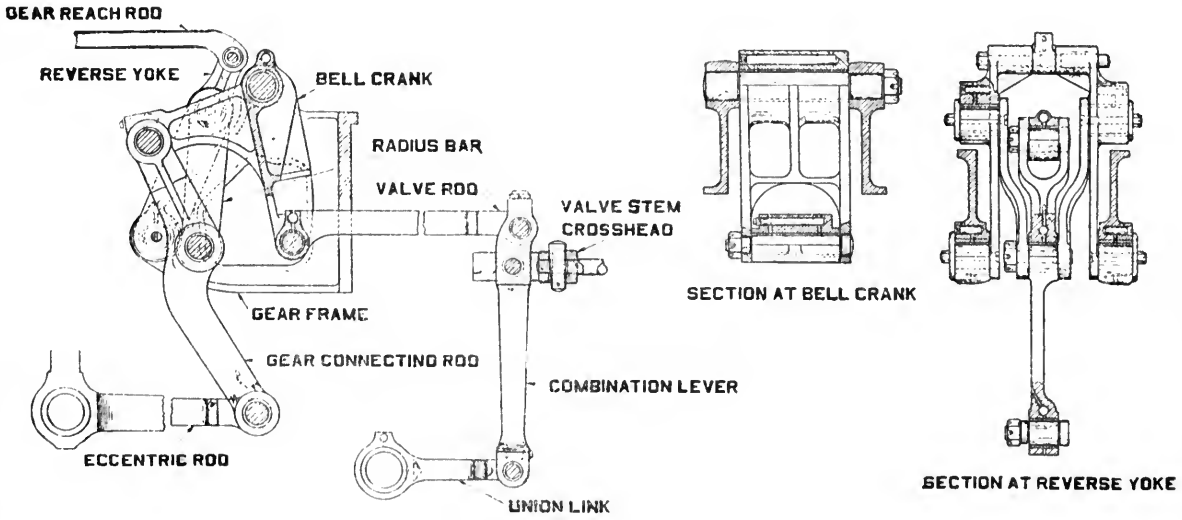
The valve stem connection with combination lever in the case of inside admission valves falls below the valve rod connection. See Figure 146.

The valve stem connection with combination lever in the case of outside admission valves occurs above the valve rod connection.

The combination lever is the medium whereby the long and short valve travels are blended together in such a way as to be most useful at the proper time.

The long travel can be seen by spotting a main pin on top or bottom working quarter and then moving the reverse lever from one corner notch to the other.

If reverse lever is placed in the mid gear notch and the engine is moved around, the short valve travel, i.e., a travel



Section Through Baker Valve Gear (inside admission).

Fig. 147

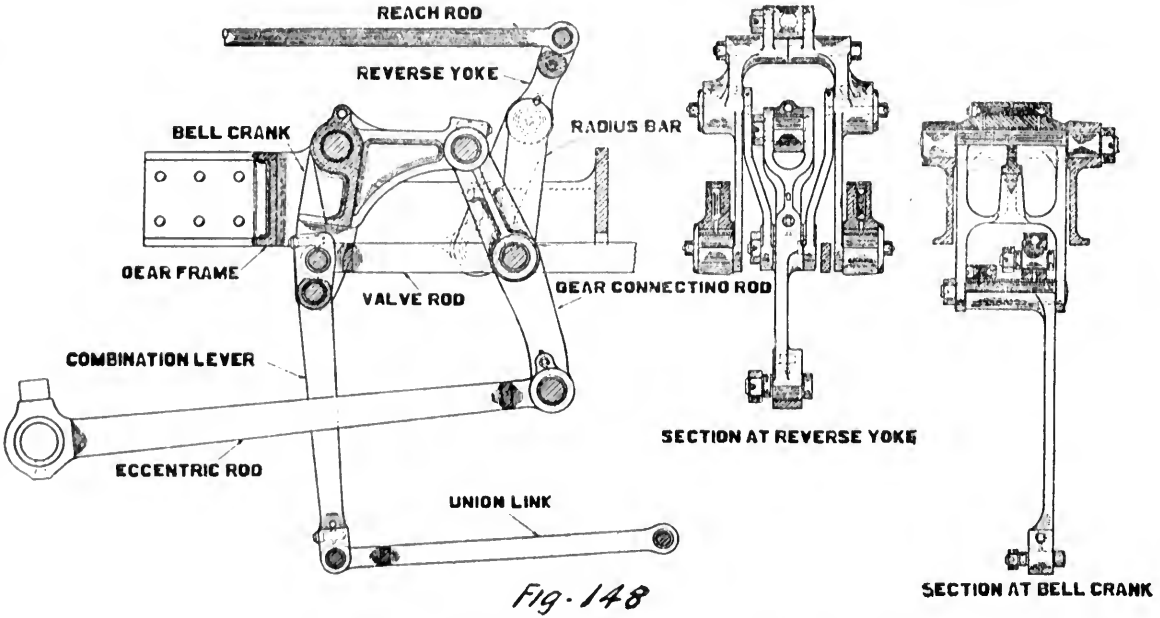


Fig. 148

Section Through Baker Valve Gear (outside admission).

equal to twice the lap added to twice the specified lead, will occur if the combination lever and union link proportions, etc., are O.K.

There is a certain slip of the lower radius bar pin which occurs in this gear and has a similar effect on valve travels as the slip of the link block in the link of a Walschaert Valve Gear.

This means that an over travel of the valve occurs on one side of the centre of the valve seat more so than on the other and is most pronounced in full gear when valves are set.

At which end the longest overtravel occurs depends whether the valves are inside or outside admission.

This difference in valve travels on either side of the centre of valve seat whilst pronounced in full gear is not detrimental as the full port openings are obtained and again the differences are considerably and quickly reduced as reverse lever is hooked up towards the mid gear notch.

When this gear has been squared up, i.e., the eccentric rods and valve stems to the full gear lead lines and the gear reach rods adjusted to equalize the hook up valve travels which render 50% cut offs, do not expect to see equal full gear valve travels on each side of centre of valve seats or bushings.

Figure 147 shows a lay out for inside admission valves.

Figure 148 shows a lay out for outside admission valves.

By kind permission of "The Pilliod Company," their original printed drawings of the "Baker Valve Gear" were used to produce figures 147 and 148 and full advantage was taken to assist in the production of other printed sketches in this chapter.

Chapter XI.

BAKER VALVE GEAR—VALVE SETTING DETAILS

A REAL benefit from a Valve Setter's viewpoint is derived in the case of "Baker Valve Gear" inasmuch that there are only two standard gears to contend with.

These two standard designs have been laid out so carefully that when the various parts are made up and assembled as per blue print, the valve setting becomes more or less an easy mark.

Gear Connecting Rod Set

The gear connecting rod for an engine with inside admission valves see Figure 147, has a decidedly different set in it as compared with one with outside admission valves, see Figure 148.

Again one needs to be careful when putting up gear connecting rods to see that the set is placed according to blue print.

Bell Crank

The upper arm of bell crank should point in the right direction from its fulcrum point, i.e., pointing away from cylinders in the case of inside admission valves. Pointing towards cylinders in the case of outside admission valve.

Motion Fitting

When valve motion is assembled in many shops, the motion fitter generally puts up the valve gear, yet it is policy for the valve setter to check up same for incorrect sets or unnccessary twists in the parts.

Port Marks, Valve and Piston Bump Marks

Port marks, valve and Piston Bump marks are found in a manner for this gear, similar to that explained for Walschaert Valve Gear.

Pistons are removed from cylinders after piston bump marks are taken and left out during valve setting.

Main Reach Rod Adjustment

When main frames are level, the length of the long reach rod, "A" is adjusted by placing the reverse lever in mid gear notch see "B," Figure 145. Lengthen or shorten main reach rod until reverse shaft arms show plumb as at "C." A change in the length of a main reach rod affects both sides of locomotive.

Gear Reach Rod Adjustment for Valve Setting

With reverse lever in mid gear notch and reverse shaft arms plumb lengthen or shorten each gear reach rod until the centres of all reverse yoke pins "D," "G" and "F" and the centre of the upper bell crank arm pin "H" are in one straight line, as near as possible by observation, as seen in Figure 145.

A change in the length of a gear reach rod affects one side of locomotive, i.e., the side on which it is connected.

Reverse Lever Travel

Stops should be arranged to allow the specified travel of the main reach rod pin which connects with reverse lever to allow of its correct travel on either side of the mid gear notch. Check up as called for on blue print.

Checking the Combination Levers with a Plumb Line

Place the reverse lever in midgear notch.

Spot the piston crosshead central between crosshead bump marks, when motion is assembled. See that long arm of combination lever is plumb or within half an inch of same.

If out of plumb, check up the lengths and location of the parts involved, i.e., bell crank, valve rod, combination lever and union link.

Application of Rollers

Rollers are put under main driving wheels in exactly the same manner and with the same precautions explained in the case of Walschaert Gear, particularly when equalizing the side play between the driving wheel centres and axle boxes and main frames, also respecting the height of the main frames, above axle boxes, when setting valves as called for on blue print.

Eccentric Rods

When adjustable eccentric rods are provided for valve setting purposes, use same until valve setting operations are completed, then make the eccentric rods intended for regular service the same resultant length, set properly and take unnecessary twist out.

Dead Centres and Crosshead Travels

Dead Centres and Crosshead Travel marks are found in the same manner as explained for other gears.

Main Rod Adjustment

Main rods are adjusted properly for length and replaced before any valve stem readings are taken with this gear.

Setting Crank Arms

The setting of an eccentric crank arm with this gear is exactly the same as detailed in the case of setting an eccentric crank arm for Walschaert Valve Gear, the front eccentric rod pin centre being used when trammelling.

Adjusting Eccentric Rod and Valve Stem Lengths from Full Gear Lead Lines

Take it for granted that Figure 149 shows a reading of full gear forward and full gear back up lead lines.

"H" and "J" are port marks and "K" is the centre of same.

"A" and "B" are forward full gear lead lines.

"D" and "E" are back up full gear lead lines.

Find the centre "C" of the forward lead lines "A" and "B" with a pair of dividers.

The centre "C" occurs 1/16" ahead of the centre of port marks.

Find the centre "F" of the back up lead lines "D" and "E" with the dividers. The centre "F" occurs 3/16" behind "K" the centre of port marks.

Now find "G" the central point between "C" and "F."

Bring the point "G" towards the centre "C" of forward full gear lead lines. In our example it amounts to "G" being pushed ahead 1/8".

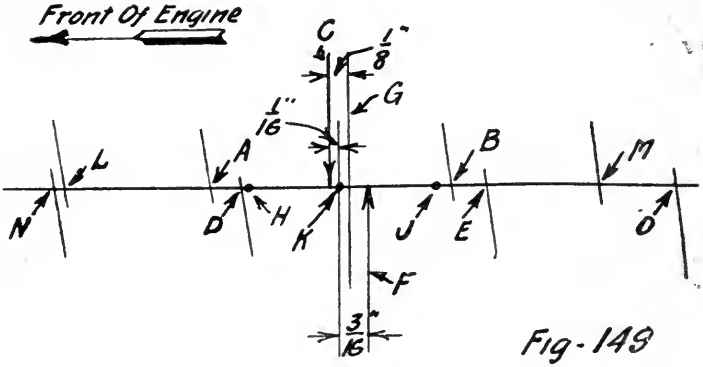


Fig-149

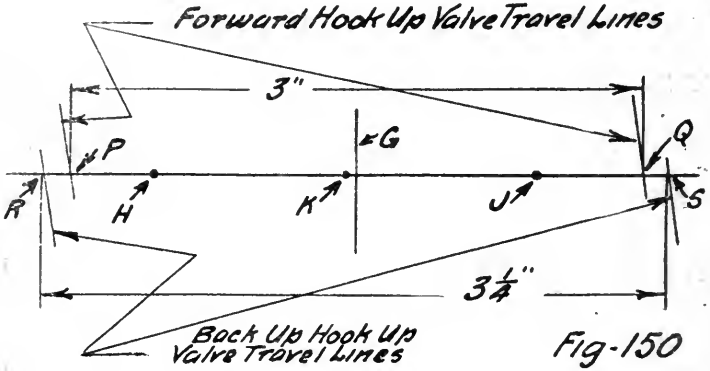


Fig-150

If we consider an inside admission valve the motion is direct in forward gear which means the eccentric rod would have to be lengthened in our example.

If we consider an outside admission valve the motion is indirect in forward gear which means the eccentric rod would have to be shortened in our example.

With Baker Valve Gears the eccentric rod length has to be changed four times as much as shown on the valve stem reading.

This means in our example that for an inside admission valve engine, the eccentric rod will have to be lengthened four times the distance between "G" and "C," i.e., 4 x ⅛" equals ½" lengthening.

If we consider Figure 149 as being taken from the valve stem of an outside admission valve, the eccentric rod would have to be shortened 4 x ⅛", i.e., ½" shortening.

Valve stem adjustment is actually measured directly from the reading, and the method is the same for inside or outside admission valves.

Bring "K" the centre of port marks "H" and "J" to "G" the central point between the centres "C" and "F" of the forward and back up full gear lead lines respectively.

In our example "K" has to be brought in a backward direction 1/16" towards "G," i.e., valve stem has to be shortened 1/16."

How to Check Lead

To check the lead for valve setting purposes, measure the distance between the front and back forward gear lead lines "A" and "B" also between the back and front back up lead lines "D" and "E."

In each case this distance should equal twice the steam lap added to twice the specified lead. If not correct, re-check the dimensions of the gear parts and the proper setting of the eccentric crank arm.

To Check Full Gear Port Opening

In Figure 149 the forward full gear valve travel lines are represented at "L" and "M" and the back up full gear valve travel lines at "N" and "O."

Measure the distance between "A" and "B."

Measure the distance between the port marks "H" and "J."

Take the distance "H.J." from "A.B." and halve the difference. The result is the lead in forward gear when the eccentric rod and valve stem lengths are adjusted to the full gear lead lines.

Measure the distance between "L" and "A." Add to this distance "L.A." the forward full gear lead. Compare the result with the width of the steam port and it can be readily observed whether a full port opening occurs or not.

The distance "L.A." added to the forward full gear lead is the distance the valve moves from the point of admission at the back port when valve is opening the port in the case of an inside admission valve.

In the case of an outside admission valve, same would apply to the port opening at the front port. The other port opening in forward full gear, also both port openings in back up full gear can be checked in a similar manner.

Final Adjustment of Gear Reach Rod Lengths

This final adjustment is by equalizing the hook up valve travels which render about 50% cut offs.

The eccentric rod lengths are adjusted from the full gear lead line reading before hook up valve travel lines are taken to adjust the length of the gear reach rods properly. This serves as a check on eccentric rod length adjustment when hook up valve travels are taken.

Let Figure 150 represent the hook up valve travel reading for the forward and back up gears taken with reverse lever in notches which allow of about 50% cut offs. The eccentric rod length has been adjusted from full gear lead lines.

Measure the distance between the forward valve travel lines "P" and "Q."

Measure the distance between the back up valve travel lines "R" and "S."

Take the shortest from the longest. In our example "P.Q." equals 3" and is less than "R.S." which shows 3¼".

The lengthening of a gear reach rod increases the valve travel in forward gear and decreases same in the back up.

To equalize "P.Q." and "R.S." the gear reach rod needs lengthening.

One turn on a reach rod knuckle having ten threads to the inch adds ⅛" to the valve travel in one gear and reduces the

valve travel in the other gear ⅛" on same side of locomotive.

Our example calls for lengthening gear reach rod one turn of the knuckle, same having ten threads to the inch, making both hook up valve travels equal to 3⅛".

Make the change at this time.

Trying the Cut Offs

When the eccentric rod lengths have been actually adjusted to suit the full gear lead line reading, lay off a new set of port marks, the centre of which is made at "G," Figure 149.

Proceed to take the cut offs in the ordinary manner before explained.

The reverse lever would be placed in a notch according to the engine to obtain approximately 25% cut offs for a passenger, 33% for a freight and about 50% for a switch engine with this particular valve gear.

Figure out the difference in cut offs, if any, required by a further change to eccentric rod and valve stem length in a manner similar to that explained for Walschaert Valve Gear.

The difference in cut offs with this type of gear when erected with ordinary care are very slight.

If the cut offs demand a further change in eccentric rod length, set the crosshead to the short cut off.

Tram in a horizontal line from the centre of front eccentric rod pin. Move engine around to arrive at the required additional half difference in cut offs and tram again from the front eccentric rod pin centre.

The difference between the two tram marks along the horizontal line is the actual amount to change eccentric rod length.

The further adjustment to valve stem lengths owing to a difference in cut offs can be determined by trammelling the valve stem and measuring exactly the change required in a manner the same as described for Walschaert Valve Gear.

The actual change required to valve stem length must surely include the first change figured from the full gear lead lines.

Important Points to Remember

Assemble the gear and check same carefully as per blue print requirements.

If not O.K. to print, remedy the error at this time.

Adjust the length of main reach rod and gear reach rods ready for valve setting.

Square eccentric rods in the first place to full gear lead lines taken and make the change before proceeding further with the setting.

Determine the change required to valve stem lengths from full gear lead lines in the first place, note it down for later reference and make new port marks, the centre of which will coincide with the common centre of the centres of the forward and back up full gear lead lines.

Do not make an actual change to valve stem lengths until valve setting final changes are made.

Adjust finally the gear reach rod lengths to equalize hook up valve travels taken with reverse lever placed in notches where approximately 50% cut offs are obtained.

Finally adjust the length of eccentric rods and valve stems if necessary to equalize the cut offs obtained when reverse lever is placed to obtain 50% cut offs in the case of a switch engine, 33% cut offs in the case of a freight engine and 25% cut offs in the case of a passenger engine.

Allow for the effect on valve gear owing to boiler expansion by lengthening the main reach rod accordingly, after valve setting is completed.

Apply the reverse lever rack stops so that the pin connecting the main reach rod to reverse lever has the specified travel, as per blue print.

Take a full card or complete motion report only when valves have been set and all changes have been made. This is only taken when especially requested.

An engine's valves are considered well set when the difference between any two cut offs taken with reverse lever in any position is not more than $\frac{3}{4}$".

Whilst the "Baker Valve Gear" is set with reverse lever placed in certain notches, it is up to the engineer's judgment to find by actual experience the economical or running notch.

Chapter XII.

VALVE SETTING ON AN ENGINE FITTED WITH "BAKER VALVE GEAR."

WHEN about to set the valves on a switch, freight, or passenger engine fitted with "Baker Valve Gear," proceed as follows, unless otherwise ordered by the shop foreman.

Obtain all the information required for shop report necessary before putting main valves in.

Blow out steam passages from boiler to steam chests.

Put main valves in.

In the case of piston valves put up the steam chest covers.

Take port marks. Allow for valve stem expansion and piston rod volume in the case of "INSIDE ADMISSION VALVES ONLY."

Find the centre between port marks and centre pop same finely.

Port marks to be taken on valve stem if convenient, if not, put up plate brackets on valve stem crossheads and fasten same rigidly.

Take valve bump marks.

Protect port marks by covering same with a loose covering of tin plate.

Put on steam chest covers in the case of "D" valves.

Blow through and properly clear steam ports from valve chests to cylinders.

Put pistons in without piston rings and cotter up properly to crossheads.

Put up front cylinder heads, tightening up same with three or four nuts.

Take piston bump marks.

Remove front cylinder heads.

Draw pistons and replace piston rings in pistons for safe keeping.

Level main frames.

Check up the valve gear insofar as it is assembled according to blue print requirements, i.e., the respective dimensions and relative positions of combination levers, union links, eccentric cranks, gear connecting rods, radius bars, reverse yoke gear frame, bell cranks, valve rods, reverse shaft arms and reverse lever.

Put up main reach rod.

Adjust main reach rod.

See that reverse lever works freely before putting up gear reach rods.

See that reverse yokes, radius bars and gear connecting rods work freely before putting up gear reach rods.

See that the gear connecting rod set is in the O.K. directions, as per print.

Put up gear reach rods.

Adjust gear reach rods as closely as possible.

See that reverse lever can be moved freely when lower ends of gear connecting rods are held steady, making due allowance for friction. This in order to locate unnecessary sets or twists which may be present in one part or another.

Now check up the travel of the main reach rod pin, which connects with reverse lever, to see if stops are adjusted to allow of the specified travel, as per blue print. If not O.K., arrange it at this time.

Piston crossheads are to be moved by hand when union links and combination levers are fitted up, before the main rods go up.

Place reverse lever in mid gear notch, crossheads in the centre of their bump marks and try out the plumb line on combination levers.

Put rollers under main drivers properly.

Equalize side play between axle boxes and wheel centres of main drivers.

Tighten up main driver horn binder bolts.

Set up main driving wedges.

Put up main rods.

Set eccentric crank arms in their approximately correct positions and tighten up with temporary bolts.

One can be sure of this at a glance. The eccentric crank pin is a little more than 90° behind the main pin in forward gear for inside admission valves and leads the main pin, by a little less than 90° in forward gear for outside admission valves.

Take out unnecessary sets and twist from eccentric rods.

Put up eccentric rods.

Use adjustable eccentric rods for valve setting purposes when provided. Before attempting to take a reading of any kind see that all motion pin nuts are tight, main rod wedges or cotters are adjusted properly, etc.

Place reverse lever in the back up corner notch, in the case of inside admission valves or in the forward full gear position in the case of outside admission valves.

With one turn of the main drivers:

(1) Pick up the four dead centres on the right main driving wheels.

(2) Scribe crosshead travel marks.

(3) See that gear does not foul in full gear.

Determine changes to make in main rods and make them right away.

Replace main rods.

Set eccentric crank arms properly.

Mark off the dowel pin holes for a check on any further movement of eccentric crank arms with respect to main pin and tighten up temporary bolts in same.

Place reverse lever in forward corner notch.

Scribe forward full gear lead and valve travel lines.

Place reverse lever in the back up corner notch.

Scribe back up full gear lead and valve travel lines.

Check up the lead collectively from these readings.

Determine changes to make to eccentric rod and valve stem length.

Make the eccentric rod length change at this time.

Note down the valve stem length change, but do not make it at this time.

Check up full port openings for each full gear from the full gear valve travels.

Make new port marks required to try the cut offs and clean out the old ones.

Place reverse lever in forward gear, hooked up to a notch which will render approximately the 50% cut offs, i.e., at about half the cylinder stroke.

Scribe forward hook up valve travel lines.

Place reverse lever in the back up hook up notch which will give about 50% cut offs.

Scribe back up hook up valve travel lines.

Equalize the forward and back up hook up valve travels thus gotten on each side of engine, by adjustment of the respective gear reach rods.

Take the cut offs with reverse lever placed in each gear respectively to obtain approximately as follows:—

For a Switch Engine, about 50% cut offs.
" Freight " " 33% "
" Passenger " " 25% "

If the resultant cut offs are practically O.K., i.e., the difference in same is not more than ¾" to 1", let her go.

If the resultant cut offs show a difference of more than 1", figure the changes required to eccentric rod and valve stem lengths to square them properly.

Re-check the dimensions of the gear, if difference in cut offs is abnormal.

Owing to the fact that two standard gears only are used, with reasonable care exercised during assembly there will be no abnormal differences in cut offs.

Make the final change to eccentric rods.

Make the final changes to valve stems, not forgetting the first change required, which was figured from full gear lead lines.

Check up rods for required changes before and after same are made. IMPORTANT.

Make sure full gear valve travels clear valve bump marks when final changes are made.

Don't trust your own brother in this game, go right after the goods yourself and then it may be the other bird's funeral, not yours.

Before leaving the engine, after valve setting proper, lengthen the main reach rod to allow for boiler expansion effect if present.

Drill eccentric crank arm dowel pin holes, drive dowels, ream holes and drive bolts in eccentric crank arms and finish off minor details, such as split pinning, etc.

If shop report demands a full card of any engine, such as lead, port openings, pre-admission, cut offs, etc., take same after all changes are made, except the allowance in reach rod length for boiler expansion.

There is one important point to remember with locomotive valve gears in order to save many unnecessary subsequent re-settings of eccentric crank arms, eccentric sheaves and eccentric rod lengths.

Set up the main driving wheels on rollers when getting ready for valve setting, so that the centre line of same is the same distance from the top rails of main frames as when boiler is loaded, etc., and engine is ready to leave the Back Shop for Road Service.

This can be determined on the first engine of any new class to be built from the blue print and checked up when first engine is turned out of the shop for trial trip.

With other engines of that class one can be guided accordingly.

Conclusion.

AFTER the "Boys" "get next" to the work detailed herein, you will almost hear certain of the "Old Timers" say "Bull"! and then very nearly see their wise old smile when they endeavour to silently convey to the younger element in the shop, by their well-seasoned facial expressions, an aversion to all "BOOK DOPE."

After a while a "Hard Nut" will "let out" the "crack," "What's he tryin' to swing? Anybody 'ud t'ink he'd 'plugged' on de Pit." "Mebbe he's seen one." "Fergit dat stuff, we can 'make it' alright, widout him 'buttin in'."

The author merely wants the younger element, or the fellow who seeks enlightenment on the game, to "Sit Up" and "Take Notice." "Dig In."

"Get Wise" to all that's goin, or possibly lose out at the next pinch when hard times hit the bunch.

Hoop 'er up a notch.

A CLEAR understanding on valve setting between employers and employees allows of a mutual benefit. The employer reduces the cost of subsequent re-settings to a minimum and the employee experiences more confidence in turning out an engine. Certain specifications are made as a rule concerning steam lap and exhaust clearance of a valve, etc., and issued to the valve setter for guidance.

An information sheet for each class of engine saves time and labor in the erecting shop as well as deriving the satisfaction that all information is obtained in the first place very carefully, i.e.:

Amount of boiler expansion effect, if any, on a reach rod.

The effect of a given reach rod or link lifter length change on lead, full gear and hook-up valve travels. Which reverse gear position to use to finally square the valve gear.

Whether to finally square the rods, etc., to full gear lead lines, full gear or hook up valve travels, or full gear or hook up cut offs.

The distance the main driving axle centre must be from the top of the top rail of main frames during valve setting, thereby saving many re-settings of eccentric sheaves, eccentric crank arms and eccentric rods owing to the difference of opinions.

When one realizes that all the necessary information has to be actually found or guessed at, more or less, during valve setting, the results of a common understanding and application at all points of a railway system are very apparent.

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